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Socio-cultural and Human Values in Science and Technology Education

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Slavko Dolinšek

Terry Lyons

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NATIONAL EXTENDED ABSTRACTS

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CLIMATE SCIENCE LITERACY

Lučka Kajfež Bogataj

University of Ljubljana, Slovenia

Abstract

Our common future is at risk from global change, especially climate change. There is a perceived need to foster awareness about climate change in schools and universities and to engage young people and future professionals in the search for local solutions for a problem with has global dimensions. Climate change will bring economic and environmental challenges as well as opportunities, and citizens who have an understanding of climate science will be better prepared to respond to both. To protect ecosystems and to build sustainable communities that are resilient to climate change a climate-literate citizenry is essential. Climate Science Literacy is an understanding of individual's influence on climate and climate's influence on individual level and society. A climate-literate person understands the essential principles of Earth's climate system, knows how to assess scientifically credible information about climate, communicates about climate and climate change in a meaningful way, and is able to make informed and responsible decisions with regard to actions that may affect climate. This paper suggests that education responses are needed which attend to provision of both appropriate educational infrastructure and relevant knowledge and skills.

Keywords: climate change, education, knowledge

1. Introduction

Climate Change is one of the most pressing global issues of our time. Human activities increasingly influence the Earth's climate (IPCC, 2007) and ecosystems (MEA, 2005). The impacts of climate change are already being observed and are projected to become more pronounced. Over the past 150 years, mean temperature has increased by 0.8 ºC globally and by about 1 ºC in Europe. Ten last years (2000–2009) were the 10 warmest years in the instrumental record of global surface temperature (since 1850). Without global action to limit emissions, the IPCC (2007) expects that global temperatures may increase further by 1.8 to 4.0 ºC by 2100. This means that temperature increase since pre-industrial times would exceed 2 °C. Beyond this threshold irreversible and possibly catastrophic changes become far more likely. To halt climate change, global greenhouse gas emissions must be reduced significantly, and policies are put in place to do so. The main sources of man-made greenhouse gases are: burning of fossil fuels in electricity generation, transport, industry and households; agriculture and land use changes like deforestation; land filling of waste; and use of industrial fluorinated gases. Bit unfortunately, even if policies and efforts to reduce emissions are effective, some climate change is inevitable. We must therefore also develop strategies to adapt to the impacts of climate change in Europe and especially beyond, since the least developed countries are among the most vulnerable, having the least financial and technical capacity to adapt. It becomes obvious that besides communication and awareness raising programs, specific educational approaches and training programs are needed to develop and promote knowledge and competencies in the field of climate change (AAAS, 2007).

2. Teaching climate change

For addressing the complex multi-stakeholder and multilevel challenges associated with climate change mitigation and adaptation an appropriate knowledge base is needed not only among public authorities and academia but also among civil society, business sector etc. in order to have problem aware constituencies in the countries of the world supporting with their attitudes and actions governments towards bold future oriented global climate change action (Burandt and Barth, 2010).

Climate and changes in climate have influenced in the past and will continue to influence what kinds of life forms are able to exist. Yet climate change is a phenomenon with which we humans have little experience, at least in historic times, and teaching about it presents special challenges to educators. Working with a complex topic like climate change is challenging both for students and teachers. Understanding the basic principles that contribute to maintaining and causing changes in weather and climate increases our ability to forecast and moderate the effects of weather and to make informed decisions about human activities that may contribute to climate change.

Climate science, like any other scientific discipline, develops through vigorous debates between experts, but there is an overwhelming consensus regarding its fundamentals. Climate science has a firm basis in physics and is supported by a wealth of evidence from real world observations. But climate change is not just an environmental problem. It is an economic problem, a political problem, an international security problem (Table 1). In a warmer world, accessibility to food, water, raw materials, and energy are likely to change. Human health, biodiversity, economic stability, and national security are also expected to be affected by climate change. Climate model projections suggest that negative effects of climate change will significantly outweigh positive ones.

Table 1. Possible impacts of climate change due to changes in extreme weather and climate events, based on projections to the mid to late 21st century (Modified after IPCC, 2007).

Phenomena and direction of trend	**Likelihood of future trend**	**Major projected impacts by sector**			
		Agriculture, forestry	**Water resources**	**Human health**	**Industry/settlement/ Society**
Fewer cold days and nights; more frequent hot days and nights over most land areas.	Virtually certain	Increased yields in colder environments; decreased yields in warmer environments	Effects on water resources relying on snow melt; increased evapotranspiration rates	Reduced human mortality from decreased cold exposure	Reduced energy demand for heating; increased demand for cooling; declining air quality in cities; effects on winter tourism
Warm spells/heat waves: frequency	Very likely	Reduced yields in warmer regions due to heat stress; fire	Increased water demand; water quality problems,	Increased risk of heat-related mortality,	Reduction in quality of life for people in warm areas without air conditioning; impacts on

increases over most land areas		danger increase	e.g., algal blooms	especially for the elderly, chronically sick, very young and socially-isolated	elderly, very young and poor; reduced thermoelectric power production efficiency; disruption to commerce
Heavy precipitation events: frequency increases over most areas	Very likely	Damage to crops; soil erosion, inability to cultivate land due to water logging of soils	Adverse effects on quality of surface and groundwater; contamination of water supply; water scarcity may be relieved	Increased risk of deaths, injuries, infectious, respiratory and skin diseases, post traumatic stress disorders	Disruption of settlements, commerce, transport and societies due to flooding; pressures on urban and rural infrastructures
Area affected by drought: increases	Likely	Land degradation, lower yields/crop damage and failure; increased livestock deaths; increased risk of wildfire	More widespread water stress	Increased risk of food and water shortage; increased risk of malnutrition; increased risk of water- and food-borne diseases	Water shortages for settlements, industry and societies; reduced hydropower generation potentials; potentials for population migration
Sea leverlrise	Likely	Salinisation of irrigation and well water	Decreased freshwater availability due to saltwater intrusion	Increased risk of deaths and injuries by drowning in floods; migration-related health effects	Costs of coastal protection, land-use relocation; Displacement of human populations, abandonment of settlements, relocation of infrastructure

Despite growing scientific evidence that global warming will have serious impacts worldwide (Richardson, 2009), lately public opinion is moving in the opposite direction. Over the past year many countries have experienced rising unemployment, public frustration with financial crisis, largely pushing climate change out of the news. Meanwhile, a set of emails stolen from climate scientists and used by critics to allege scientific misconduct may have contributed to an erosion of public trust in climate science. It is also clear that public understanding of climate change fundamentals - that it is happening, is human caused, and will have serious consequences for human societies and natural ecosystems around the world - is heading in the wrong direction. Students of all ages (including college students and adults) still have difficulty understanding what causes climate change. These findings underscore the critical need for more and improved climate change education and communication (Bangay and Blum, 2010).

Climate change science is complex and can certainly be confusing (Figure 1). It is highly interdisciplinary, cutting across numerous disciplines. Many if not most science educators teaching traditional biology, chemistry and physics may never have been trained in the basics of climate science. Earth sciences have also been traditionally rooted in geology, where rocks rule and deep time prevails. Climate fits between geological and meteorological processes, and all too often falls through the disciplinary cracks. There are many well-written and authoritative books for a general audience that can help educators and others understand the science of climate change and its environmental and societal impacts. Also there is an abundance of information and materials available online for science educators and communicators, like official site of the Intergovernmental Panel on Climate Change from which all of the IPCC reports are available for download. Some excellent Web sites, which provide access to a variety of authoritative resources from government, academic, and scientific organizations are given in Table 2.

Table 2: Some excellent Web sites, which provide access to a variety of authoritative resources from government, academic, and scientific organizations

Institution (alphabetical order)	**Web site**
AAAS Global Climate-Change Resources	http://www.aaas.org/climate
European Environment Agency	http://www.eea.europa.eu/themes/climate
Hadley Centre for Climate Change : the UK's official centre for climate change research.	http://www.metoffice.gov.uk/climatechange/science/hadleycentre/
Intergovernmental Panel on Climate Change (IPCC)	http://www.ipcc.ch/
James Hansen : articles and presentations on timely and important issues in climate science.	www.columbia.edu/~jeh1
National Oceanic & Atmospheric Administration (NOAA), National Climate Data Center	http://www.ncdc.noaa.gov/oa/climate/globalwarming.html www.education.noaa.gov
National Center for Atmospheric Research (Colorado USA)	http://www.ucar.edu/research/climate/ http://www.eo.ucar.edu/basics/index.html
Potsdam Institute for Climate Impact Research (PIK)	http://www.pik-potsdam.de/
RealClimate: Climate scientists respond to issues that arise in the popular discourse	www.realclimate.org
University of Copenhagen	www.copenhagendiagnosis.com
World Climate Research Programme (WCRP)	http://wcrp.wmo.int/wcrp-index.html

Most students learn the basics of weather at a young age. It’s a good place to start—observing local weather events and seasonal changes. But climate, while obviously related to weather is inherently different, requiring different theories, models and pedagogy. In many countries, few teachers have training—or the time or mandate—to dig deeply into climate processes. When climate change is taught, it is often ad hoc, emphasizing polar bears and carbon calculators over in-depth understanding of carbon, climate and complex interactions. This is a pity, because interest in climate change issues provides a great opportunity to talk about basic science, as well. Furthermore climate change science is one of the first science topics where a social science physical science collaboration is required.

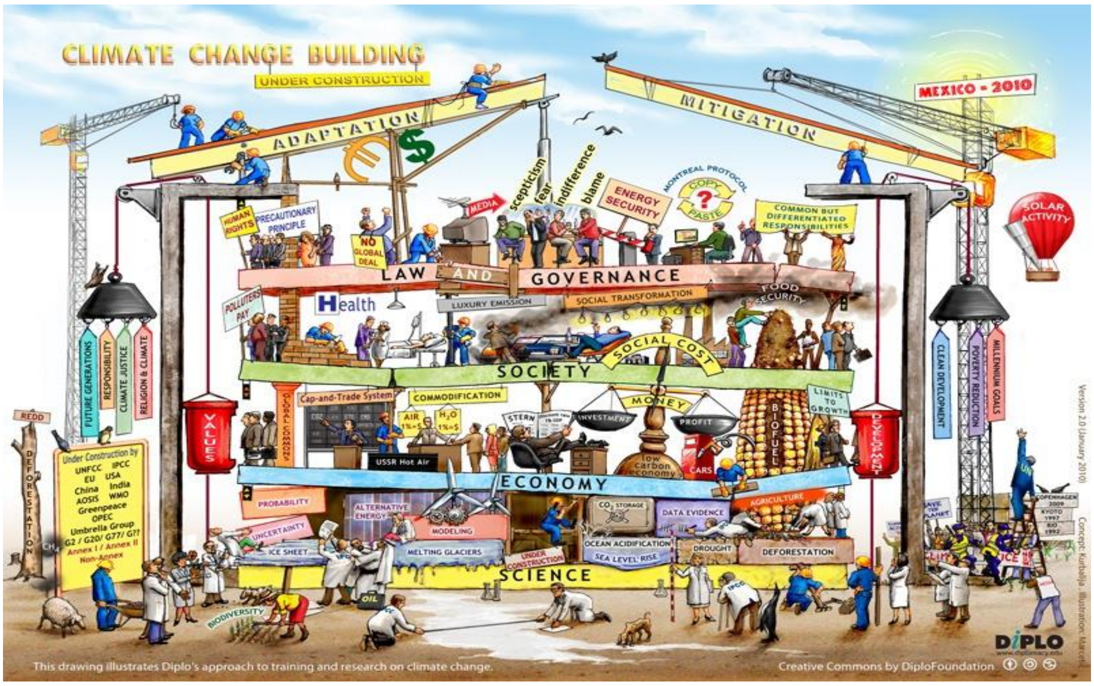

Figure 1: Climate change science is complex and can certainly be confusing (http://www.diplomacy.edu/climate/)

However, for the young people in our communities and classrooms who are learning about the planet, acquiring skills and insights into the complex socio-environmental and economic realities of the world, knowing the basics of climate science is imperative. Scientific information on climate change must be disseminated in a way that allow is to be broadly understood, including elements related to its environmental, social, economic and policy aspects to schools and universities around all continents. Students should have a chance to discuss the problems, barriers, challenges and chances and potentials related to climate change both in the local and regional level but also globally. This will raise awareness among secondary and university students on the complexity of matters related to climate change and the need for personal engagement and action.

Human-induced global change is really a symptom of outdated ways of thinking, worldviews, and ideologies that are not only unsustainable but threaten the very survivability of the human species and environmental systems we depend on. For centuries, people thought that earth processes were so large and powerful that nothing we could do would change them. This was a basic tenet of geological science: that human chronologies were insignificant compared with the vastness of geological time; that human activities were insignificant compared with the force of geological processes. And once they were, but no more. There are now so many of us cutting down so many trees and burning so many billions of tons of fossil fuels that we have indeed become geological agents. We have changed the chemistry of our atmosphere, causing sea level to rise, ice to melt, and climate to change. There is no reason to think otherwise. Discovering ways to encourage whole systems, holistic thinking and behaviour is perhaps the ultimate conundrum of this generation as we move to address the phenomenal challenges of the 21st century.

How to better teach students about climate change has been an issue of great concern among climatologists and also educators. In recent years educators' awareness of climate change has continuously improved. However, majority of countries haven't yet set up a systematic educational program on climate change. The topic is indeed complex because the Earth's systems are complex, and scientists themselves are not at all certain of the potential ramifications of our interference with these systems. Formidable from an educator's point of view is the intangibility of climate change: its global scale and seemingly slow progression make it a phenomenon that does not easily lend itself to classroom demonstration. And teachers and students who wish to take action on climate change find themselves up against the ingrained habits and attitudes of an industrial society created and powered by fossil fuels and supported by political inertia in establishing regulatory policies to curb greenhouse gas emissions.

It must be understood that climate science literacy is an ongoing process. Students are not expected to understand every detail about all of the fundamental climate science. Full comprehension of these interconnected concepts will require a systems-thinking approach, meaning the ability to understand complex interconnections among all of the components of the climate system. Moreover, as climate science progresses and as efforts to educate the people about climate's influence on them and their influence on the climate system mature, public understanding will continue to grow.

But teaching about and taking action on climate change may not be as difficult as it seems. Teachers and students should explore some of the key questions related to climate change: What are its causes? What might we expect? What are governments doing about it? And, most important, what can schools and students do about it? In working with young people, teachers have a great many opportunities to address these vitally important questions. Many topics that would be part of a study of climate change are already part of most primary school curricula: these include, for example, technology topics such as energy systems; social studies topics such as political decision-making; or geography and science topics such as weather systems, photosynthesis and decomposition, and adaptations of plants and animals to specific habitats and climatic conditions. Moreover, many teachers and students are already engaged in activities that are helping to reduce their own and their schools' greenhouse gas emissions: planting trees near the school building, conserving energy and water, reducing waste, walking or cycling to school instead of driving. It is only a small step to incorporate discussion of climate change into these curricular areas and activities. Promoting climate literacy through informal science learning environments is important, as well.

Regarding climate change society has three options. First is mitigation, which means measures to reduce the pace & magnitude of the changes in global climate being caused by human activities. Examples of mitigation include reducing emissions of GHG, enhancing “sinks” for these gases, and “geoengineering” to counteract the warming effects of GHG. Second choice is adaptation, which means measures to reduce the adverse impacts on human well-being resulting from the changes in climate that do occur. Examples of adaptation include changing agricultural practices, strengthening defense against climate-related disease, and building more dams and dikes. Suffering the adverse impacts that are not avoided by either mitigation or adaptation is the third option. Mitigation and adaptation are both essential. Human-caused climate change is already occurring and is already dangerous. Adaptation efforts are already taking place and must be expanded. But adaptation becomes costlier and less effective as the magnitude of climate changes grows. The greater the amount of mitigation that can be achieved at affordable cost, the smaller the burdens placed on adaptation and the smaller the suffering.

3. Conclusions

Climate change is not just our grandchildren’s problem or our children’s problem. It is our problem. We and our predecessors caused it. We have the responsibility to address it. If not addressed with adequate wit, wisdom, and resources, the disruption of global climate will thwart societal aspirations everywhere. It will erode well-being where it now exists and it will prevent the attainment of well-being everywhere else. It will undermine any prospect for international peace and stability. The costs of addressing it will be far less than the costs of ignoring it. The countries and companies that take the lead in turning challenge to opportunity & cost to benefit will help themselves and help us all.

Education is a critical element in the response to the challenges of climate change. Climate is an ideal interdisciplinary theme for lifelong learning about the scientific process and the ways in which humans affect and are affected by the Earth’s systems. This rich topic can be approached at many levels, from comparing the daily weather with long-term records to exploring abstract representations of climate in computer models to examining how climate change impacts human and ecosystem health. Learners of all ages can use data from a range of physical, chemical, biological, geographical, social, economic, and historical sources to explore the impacts of climate and potential adaptation and mitigation strategies.

Learning about climate change not only provides relevant literacy but it also allows empowering, enabling, motivating, informing, and educating the public around the technical, political, and social dimensions of climate change. In addition, unlike literacy which has a uni-directional connotation, engagement is as much about informing the public as it is about also informing experts and decision-makers. Communication should be viewed as a two-way process - with frames providing the context for dialogue - where experts and decision-makers seek input and learn from the public about preferences, needs, insights, and ideas relative to climate change solutions and policy options.

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DEVELOPING SOCIO-CULTURAL AND HUMAN VALUES IN SCIENCE AND TECHNOLOGY THROUGH SOCIOSCIENTIFIC ISSUES

Dana L. Zeidler

University of South Florida – Tampa, USA

Zeidler@usf.edu

The overarching mission of IOSTE is to encourage the peaceful and ethical use of science and technology in the service of humankind – it explicitly opposes the use of science and technology by government or other

organizations for military purposes against civilians. Key objectives that align with its mission include fostering dialogue that: 1) Highlight S&T education for citizenship and for informed, critical, and active participation in democracy; 2) Emphasize the cultural and human values of S&T; 3) Advance S&T education for a just and sustainable development; 4) Encourage the peaceful and ethical use of S&T in the service of humankind; and 5) and consider how S&T education can contribute to the fight against poverty, discrimination and injustice (http://www.ioste.org/). The purpose of this presentation is to argue the case that the use of socioscientific issues is not only consistent with the development of socio-cultural and human values in science and technology, but is necessary to fulfill the mission of IOSTE as well as the über goal of science education – achieving scientific literacy.

The basic premise driving our research on the development and implementation of socioscientific issues (SSI) is fairly straightforward; that contextualized argumentation in science education may be understood as an instance of education for citizenship. If one accepts this premise, then it becomes essential to present to students the humanistic face of scientific decisions that entail moral and ethical issues, arguments and the evidence used to arrive at those decisions. Separating learning of the content of science from consideration of its application and its implications (i.e. context) is an artificial divorce (Aikenhead, 2006; Zeidler, Sadler, Applebaum & Callahan, 2009). The SSI movement focuses specifically on empowering students to consider how science-based issues and the decisions made concerning them reflect, in part, the moral principles and qualities of virtue that encompass their own lives, as well as the physical and social world around them.

In his extensive review of literature regarding scientific literacy (SL), Roberts (2007) provides an important distinction between two generalized views of SL: Vision I emphasizes aspects of academic content related and aligned to the goals of science, while Vision II emphasizes an approach that is broader in scope, involving personal decision-making about contextually-embedded science and social issues. It is within Vision II that socioscientific issues are embedded, although our investigations contain features of SSI reasoning that arguably surpass Vision II. The "heuristic device" (p. 775) employed by Roberts works well to contrast the field's perceptions often associated with the construct. Because we realize that it is necessary to parse out components of a construct (such as SL) in order to clarify its constituent parts, we acknowledge that any alternative heuristic we might invoke would undoubtedly frame the issue in a different orientation. Hence, our corresponding argument can best be located in a more comprehensive, and necessarily more inclusive stance of Vision II. In other publications, we have argued (Sadler & Zeidler, 2005; Zeidler, 1984; Zeidler & Keefer, 2003; Zeidler & Sadler, 2008a; 2008b; Zeidler, Sadler, Simmons & Howes, 2005) that any conceptualization of the intention and significance of scientific literacy falls short of the mark, if moral reasoning, ethical considerations and character development are not part of our understanding of SL.

The Socioscientific Issues framework seeks to involve students in decision making regarding current social issues with moral or ethical implications embedded in scientific contexts (Sadler, 2004; Zeidler & Keefer, 2003; Zeidler et al., 2005). These issues provide students with opportunities for active reflection upon an issue and examining how the issue relates to their own lives, as well as the quality of life in their community (Driver, Leach, Millar, & Scott, 1996). It is equally plausible that certain ethical issues can become the context of embedded scientific content and certain Nature of Science (NOS) tenets (Abd-El-Khalick, 2003; Sadler, Chambers & Zeidler, 2004; Zeidler, Sadler, Applebaum & Callahan, 2009; Zeidler, Walker, Ackett & Simmons, 2002). Hence, our central argument is that SSI can provide an epistemological context for students' conceptual understanding of important scientific and social matters, thereby serving as a venue for the development of character and reflective judgment. In doing so, a more inclusive stance of Vision II SL becomes necessary.

We have, therefore, suggested that the vision of SL we wish to advance is more aligned with Vision II, but pushes the envelope a good deal further along Robert's original continuum. The rationale behind our use of the term *functional* scientific literacy is one that would be sensitive to both dominant and alternative normative views of SL. To the extent that the emphasis on moral growth, reflective reasoning and the formation of character is part and parcel of a radically different notion of SL (fundamentally different from Vision 1 and distinctly different from Vision II), functional SL in the sense that we advocate, is contextually and culturally sensitive to the needs of the learner. This perspective is consistent with the sociocultural perspective of SL that Sadler (2009) advances; it prioritizes enculturation and practice. Within this view of SL, the activity of science as practiced in any culture is legitimized, and students have access to the norms of that culture wherever it may be found. Kelly (2007) is certainly sensitive to this view inasmuch as he recognizes the selection of goals for scientific literacy with particular outcomes of citizenship. Given the pluralistic nature of societies, he questions whether a focus on "building public reason" with its emphasis on critical discourse should trump a focus on selecting a priori outcomes of what students should know about science. Under our functional view of SL, a priority is given to investigating how SSI may develop both SL and character through experiences that maximize opportunities for citizenship (Berkowitz, 1997; Benninga, Berkowitz, Kuehn & Smith, 2003; Berkowitz, Battistich & Bier, 2008).

One aspect of our research has examined how elements of students' argumentation including related aspects of fallacious errors in judgment play out in resolving what are essentially moral claims embedded in SSI (Walker & Zeidler, 2007; Zeidler, 1997; Zeidler, Lederman, & Taylor; 1992; Zeidler, Osborne, Erduran, Simon, & Monk, 2003). A second aspect of our research has focused on how variations in subject matter knowledge (i.e. science content knowledge) across different grade levels affect students' reasoning on SSI (Dolan, Nichols & Zeidler, 2009; Greely, Lodge & Zeidler, 2009; Sadler & Donnelly, 2006; Sadler & Fowler, 2006; Sadler & Zeidler, 2004; Sadler & Zeidler, 2005b; Zeidler, Walker, Ackett & Simmons, 2002). A third venue of research has attempted to shore-up and clarify aspects of theoretical and conceptual frameworks connected with SSI (Fowler, Zeidler & Sadler, 2009; Sadler, 2004a; Sadler, 2004b; Sadler, Barab, & Scott, 2007; Sadler, Chambers & Zeidler, 2004; Sadler & Zeidler, 2005a; Zeidler, 1985; Zeidler & Keefer, 2003; Zeidler & Nichols, 2009; Zeidler & Schafer, 1984; Zeidler, Walker, Ackett & Simmons, 2002). Central to all these studies is the importance placed squarely on understanding how students reason and react reflexively to variant evidence and beliefs. In doing so, we provide opportunities for students to negotiate and argue with others and ultimately reflect as they form judgments about controversial issues.

In doing so, we are able to begin a journey of prudent steps that lead to the formation of conscience. The education of a public is essentially a normative process and a moral task insofar as decisions about desirable ends are inextricably linked to pedagogical means. It is one thing to ask, as in moral philosophy, what is the nature of the good? It is quite another to ask, how does one get that way? The latter question falls in the domain of moral education (Green, 1999). To the extent that we, as educators, are concerned about guiding our students to question what is right, proper, and necessary, then we *also* need to provide the conditions necessary to develop character. To suggest that a central tenet of science education is the cultivation of scientifically literate citizens is to establish, a priori, a set of implicit norms about our roles as educators in fostering the formation of an "informed" public and subsequently the establishment of a collective social conscience. It is important to note that this process of normation does not prescribe rules of behavior (i.e. how one ought to behave); rather the process encourages individuals to *think about* what they ought to do. The difference is not merely semantic. While the former interpretation compels people to be compliant and obedient, the latter view is aimed at developing the formation of conscience through the exercise of reflexive judgment. Reflexive judgment, understood in this context, is primarily concerned with self-evaluation. Did I do that well? How poorly did I perform? Could I have done that better? While such questions are not ordinarily thought of as *moral* matters, they are concerned with a type of self-evaluation not unlike Flavell's (1987) use of "metacognition" or Dewey's (1910) notion of "reflective judgment." We can think of this as thinking turned back on itself relative to one's own gauge of virtue. Since virtue may be equated with excellence (note Book Two of Aristotle's *Nichomachean Ethics*, 1998), one can argue that a virtuous life is one filled with deeds par excellence. The desire to consistently hold one's actions up for internal scrutiny is a fundamental feature of conscience.

The cultivation and development of self-evaluation understood in this manner is a feature of SSI. The SSI movement focuses specifically on empowering students to consider how science-based issues and the decisions made concerning them reflect, in part, the moral principles and qualities of virtue that encompass their own lives, as well as the physical and social world around them. If we want students to think for themselves, then they need opportunities to engage in informal reasoning, discourse, argumentation, and practice utilizing evidence-based reasoning within their science classes. Accordingly, we must present topics that challenge students' normative expectations and that compel them to engage one another in the resolution of differences existing among individuals via argumentation and discourse during face-to face interactions. Such reasoning deals with what Rest, Narvaez, Bebeau and Thoma (1999) term issues of "micromorality." Moral reasoning, then, may arise out of discourse and argument. It is, on the one hand, a type of technical competence whereby students can evaluate potential decisions with respect to how well those decisions attend to potential short and long-term future consequences. But on the other hand, it extends beyond mere technical competence insofar as the student must consider how well their decisions attend to past historic inequities; such decisions may then be said to be just, fair and equitable. Such reasoning, then, truly arises out of a special type of reflexive judgment that transcends technical competence in decision-making, because it adds to the formation of conscience and empathy, surely necessary in the larger picture of moral education, norm acquisition and character formation. It would be prudent for science educators to understand that the future and quality of life within our social institutions is indelibly linked to the quality of educative experiences we provide for our children.

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THE SCIENCE CURRICULUM: A contest of values, purposes, interests and possibilities

Peter J Fensham

QUT and Monash University

The theme of my lecture is *THE SCIENCE CURRICULUM AS A CONTEST,* and in it I will share examples of *how that contest has been played out historically, what the contests are today, who are the contestants,* and *what is at stake.*

That the science curriculum is a contest should not be surprising, because the word "CURRICULUM" is derived from a Latin word that in Roman times was associated with the "race course". It referred both to the running of the race and to the nature of the race. CURRICULUM was also used in a life sense to refer to the series of deeds and experiences through which Roman children grow to become adults.

Each of these meanings is reflected in how the word is used in formal school education and in science education in particular. Formal education for young people takes a very large proportion of a country's national budget, so it is no surprise that the curriculum for that education is contested. Furthermore, the link between science and technology and the economy and political status of countries is now so strong that the contest for the science curriculum is particularly intense.

Sometimes "curriculum", refers to a statement of the intended knowledge, skills and attitudes for learning and to the pedagogies that are employed by teachers to facilitate the learning. In this lecture I am more concerned with the "racecourse" sense of the Science curriculum – its intended content.

David Layton (1973) introduced me to the idea of the science curriculum as a contest in his seminal book **Science for the People**. In the 1840s a village school master in England gained the interest of a senior inspector of schools for his introduction of basic science for his pupils, destined for agricultural labouring. This seemingly sensible innovation was quickly opposed by an array of powerful voices. The inclusion of science more widely in schooling was defeated.

It was not right to equip the working classes with knowledge at that time unavailable in the schooling of the upper classes. Science was not morally uplifting, compared with the humanities. The scientific community disagreed about which aspects of science were most appropriate. Geology, important for understanding soils but also for the expansion of the railways and mining, could lead to unhelpful religious antagonism, a foresight of what would arise over natural selection a few years later.

This early contest over the curriculum for science featured two issues- *science as useful knowledge* and *science as moral knowledge*.

These issues about the role of the science curriculum are still contested today, albeit with changing definitions, changing political contexts, and new sets of contestants.

Science as useful knowledge

The teaching of the sciences in schooling emerged again towards the end of the 19th C and now less contentiously, because their role was to facilitate the transition of the tiny percentage of students who would go on to university science studies. The curriculum of these sciences now had the simple purpose of being preparatory. Contestants in this period were academic scientists and usually well educated science teachers, and their contest was:

> *What is the basic knowledge in the sciences as preparation for science-bound students?*

This single preparatory purpose was still evident in the major efforts in the 1960s to bring the school science curriculum up-to-date (in line with university sciences) after its neglect due to the 1930s economic depression, World War 2 and its aftermath. The priority of this curriculum development was still the reformulation of the sciences for the academically selected, science-bound students. The contestants were older science teachers and the interested academic scientists. The issue was:

> *How can the now conceptual basis of the sciences be included in what were essentially descriptive science curricula?*

This conceptual basis, backed by powerful scientific and political forces (the post Sputnik era), won at the expense of more interesting descriptive science, its applications, and the historical dimension, the main means for teaching the nature of science. Nevertheless, this era of curriculum later first recognised the need for school courses in science or the sciences for students more generally, and an array of interesting materials to support such alternative science curricula were produced.

By the 1980s, more and more students were staying for longer in secondary education, and a series of national reports with the generic theme of *Science for All* were produced (Fensham, 1988). Serious concerns about the inadequacy of the "academically-oriented science" were raised by science educators, a newly emerging group of academics. Opposing them were academic research scientists and elite science teachers. On each side, there were other influential but vacillating stake holders from the society itself. The issue for this curriculum contest was:

> *How can the school science curriculum meet the needs of the science-bound minority and of all students in an increasingly, S&T influenced society?*

For almost thirty years, we in the science and technology education communities, have lived with this contest. IOSTE, initiated in Canada in 1979 has been a major forum for debating this contest, so it is interesting that the report, **Science for All Canadians**, uniquely added two other societal demands on school science – *the world of work* and *moral education.* (Science Council of Canada, 1984).

Suggestions for resolution

Douglas Roberts (1982) found at least seven different purposes for school science in the reforms of the 1960/70s. He pointed out that if we try to teach for all these purposes at the same time, some will be inevitably be lost, and the established one of providing preparatory, foundational knowledge is likely to win. Why not, he argued, see the years of schooling as made up of stages in which science teaching sets out to achieve just one or two of these purposes (the *curriculum emphasis)* that relate especially to the learners' needs at that stage.

A number of countries have explored, with varying degrees of success, this idea of '*curriculum emphasis'* as a compromise solution to the contest. At the senior levels of schooling many countries have developed different science curricula for the same level of schooling. These efforts to provide a better science curriculum for the citizen-bound needs of students inevitably fail if educational status remains with the specialised science disciplines. Thailand, in the 1980s employed an unusual solution to the contest with great success, and now 21st Century Science in England and Wales has offered an attractive solution to the curriculum contest in the senior years.

Following the *Science for All* reports, various reformers sought to resolve the contest by developing innovations for school science under the banner of Science/Technology/Society (STS)(Solomon and Aikenhead, 1994). The more cautious reformers simply added examples of societal applications of science (technologies) as optional extras to the existing science content. The more radical allowed these examples of technologies and society to have a more determining influence on the Science to be taught. This promising resolution was quickly lost when Technology was established as a new subject for mainstream schooling, with its timely subsumption of computer-based elements. Without Technology, Science's bridge to Society was lost, and the proponents of preparatory conceptual science won again, and now their view stretched through all the years of schooling.

After a decade the negative consequences of this curriculum on the interest of students in science and science careers have become increasingly evident, re-opening the contest.

One suggestion has called for a curriculum, that gives more attention to the 'stories of science' and engages learners more discursively. Another is described as context-based science and Roberts (2007) elaborated the contest in terms of two visions for scientific literacy. Vision I looks inward to Science itself and leads to the academic, preparatory science curriculum. Vision II looks outward to situations in society involving science and technology and for allows these to become determining for the school science curriculum.

International comparisons of science achievement are now influencing the contest, with the IEA's TIMSS project reinforcing the curriculum of Vision I, whereas the OECD's PISA Science is more identified with a Vision II of science learning.

Since 2000, the contest over the science curriculum as useful knowledge has become more confusing as powerful advocates from the world of work and from the Knowledge Society call for generic competencies in learners. The science curriculum's reliance on the acquisition of established knowledge makes it vulnerable to such new contestants (Gilbert, 2005).

Science education as a Contest about moral knowledge

Lee Shulman, in devoting his 1987 Presidential address to the American Education Research Associatiion to teachers' "pedagogical content knowledge" (PCK), unknowingly built a bridge across an educational chasm. This chasm divides educational traditions about curriculum that have emphasised very different views of the curriculum "racecourse". One sees schooling in terms of *an induction into subjects* and the other sees schooling as *life and character formation – a sense of education that the* German words, Bildung and Didaktik, very much embody.

In one tradition the curriculum of content knowledge for a discipline is determined by the educational system , at a level beyond the school and individual teacher. The teachers' responsibility is simply to teach this given content. In the other tradition it is the teacher's responsibility to select from the disciplinary knowledge both what should be taught and its teaching. This fundamental difference can be seen in five principles that are well known in the Didaktik tradition of teaching disciplinary fields like the sciences (Klafki, 1995). Principles 1&2 are guides to choosing the science content so that it will enhance the learner's formation. Principles 3,4,&5 are about the subsequent teaching. Where the first tradition is strong, science teacher education begins with the latter three principles and ignores the first pair entirely.

In one tradition the content for teaching is very much identified with the content and logic of the discipline itself. In the latter, the disciplinary knowledge is recognised as not automatically what is best for the educational purpose of schooling, and needs to be "selected and translated'. Two curriculum documents published in 1994 epitomised the chasm. One set out the curriculum of school education like the decathlon events in the Olympic Games – a "racecourse" consisting of learning a number of different knowledge subjects. The other, as a **Core Curriculum** for education in Norway, follows the life sense or "moral" sense of CURRICULUM as a series of events leading to visionary goals of a rounded and moral person.

These two traditions should not simply associated with particular national systems of education, but they do, in different systems differentially influence how the curriculum contest in a given country is played out. Asian countries, commonly refer to the place of values in the curriculum. Western countries tend to associate student interest in a subject with its teaching and not as a determinant of the curriculum's content. Roberts' Vision II for scientific literacy and the PISA Science test are now being criticised because they overestimate the science component of real world S&T situations. Zeidler and Sadler have pointed out that these socio-scientific situations (SSI) often involve other components including ethical ones that need to be recognised the teaching of their science. Yet another new aspect of the curriculum contest about science as moral knowledge derives from the Big Challenges facing science and technology. This new aspect is the uncertain nature of the science involved. The frustration of so many over the global warming issue at Copenhagen is directly related to the failure of our science curricula to include "risk", uncertainty, and the precautionary principle. Resolving this contest may be our greatest challenge as science and technology educators.

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”THE SECOND SEX” IN SCIENCE WHY ARE WOMEN STILL UNDER-REPRESENTED IN SCIENCE AND TECHNOLOGY, WHY DOES IT MATTER, AND WHAT CAN WE DO ABOUT IT?

Ellen Karoline Henriksen

Department of Physics, University of Oslo

ABSTRACT

In this paper, Beauvoir's (1949) description of women as "the second sex" is used as a starting point for exploring the reasons for, and possible ways of handling, the under-representation of women in science, tchnology, engineering and mathematics (STEM). A brief description of the situation is given, and four reasons are proposed why it is important to seek a greater gender balance in the STEM fields. Building on research regarding young people's (girls' in particular) relationship and attitudes to science, the expectancy-value model of educational choice (Eccles & Wigfield, 2002) is used as a framework for exploring the reasons why many women (and men) opt away from science. Based on the findings presented, the paper goes on to point out possible ways forward in order to increase the diversity of personalities that may feel attracted to science and technology so that the future workforce within these fields will not only be greater in numbers and more even in gender distribution, but will generally include a greater multitude and variety of outlooks, experiences and aims.

Keywords: *Gender, science, technology, educational choice*

INTRODUCTION: WOMEN AS "THE SECOND SEX" IN SCIENCE?

In 1911, Marie Sklodowska Curie became the first person to have earned two Nobel prizes – for her investigation of radioactivity and discovery of new radioactive elements. Curie is arguably the most well-known female scientist in history, and her story still holds fascination, not least because of her struggle to make a proper place for herself within the scientific community. She is seen on photos from physics conferences at the time, usually the only woman. In a Norwegian science textbook for 16-year-olds, the reader gets to know how Curie was working: often in the kitchen, with the result that her cookbook is still so radioactive that it has to be displayed behind thick glass in a museum.

In 1949, Simone de Beauvoir wrote the groundbreaking book "The second sex" (Beauvoir, 1949), thereby laying the premises for a discussion of what it means to be a woman and how the feminine is construed not as an experience or a mode of being in and of itself, but rather as being something different from a man. She describes how the man defines what a human being is and should properly be – or, transferred to our present context, what a *scientist* should be. The man is seen as *transcending* his boundaries, developing, expanding his knowledge and challenging his abilities, shaping nature and culture. Woman, on the contrary, has been seen (says Beauvoir) as *immanent*, that is: stagnant, non-transgressive, with no drive to challenge and develop her abilities to the fullest (see for instance Pilardi (1999))– and, in our context, with no proper place in science but as an exception. Beauvoir goes on to show how this is connected with the situation of women in society, where they are subordinate to men, and to argue that women can strive towards greater freedom and participation.

Today, 60 years after "The Second Sex", economic and societal conditions have changed and at least in Western countries, some of the constraints described by Beauvoir would seem to have been removed or at least greatly reduced. However, women continue to be "the second sex" in science: The male researcher is still the norm and the "female mathematician", for instance, is very often presented as exactly that: An oddity, a phenomenon calling for attention. Young girls and women continue to make educational and career choices that resemble those of their grandmothers – although today's young women give different *reasons* for their choices.

Thousands of pages have been written about women in science, and had there been a simple explanation and an easy fix for the under-representation, it would surely have been found long ago. Nonetheless, I would like to contribute to this ongoing debate with some results from recent research, set in the framework of a model for educational choice, in the hope that this structure can lead us towards some possible lines of action.

My contention at the outset of this article is that women are still "the second sex" in science, in that their participation is still limited and is seen as an exception from the norm. What is the potential contribution of these female "others" in science? Why should we seek to have more women transcend their individual, personal borders as well as the borders of scientific understanding? Why do young girls in free and enlightened societies and in the age of information technology, still shy away from the subjects and careers that are likely to shape our everyday lives and possibly the destiny of our planet?

I will look at the current situation for female representation in science and the reasons why we should seek a higher participation of women in these fields. From there I will move on to how a possible choice of a science education and career is evaluated and construed by modern young women, using the theoretical framework provided by Jacquelynne Eccles and colleagues. I will refer to research findings both from others and from two research projects I am currently involved in: The Norwegian "Lily" study (Schreiner, Henriksen, Sjaastad, Jensen, & Løken, 2010) and the international IRIS project (IRIS, 2010). Finally, I will use these findings as a point of departure for suggesting some ways forward.

Osborne et al. (2009) have reviewed research documenting that girls' disenchantment with science starts before age 14, and they point out "the need to ensure that the teaching of science in middle schools is of the highest quality and that considerable effort is needed to inform students of the potential career pathways afforded by the study of science ". This is extremely important for all of us engaged in science education to bear in mind, and it will form a backdrop for the whole of the present paper. However, in this paper I will concentrate most on what happens a bit later, when the girls (or rather: young women) are in the process of choosing post-secondary education, bringing with them experiences from school and home background into the decision process.

Before I move on, I would like to say that although I use the term "science" in the heading and often throughout this paper, the discussion is generally valid also for mathematics and the technological disciplines. Thus, most of the times where I write "science", it could easily be exchanged with "science, technology, engineering and mathematics" (STEM). Throughout the paper, my focus is on those disciplines that have a recruitment challenge and an under-representation of women. Thus, my arguments will relate mainly to the mathematical, physical and technological disciplines, and less to the life sciences.

A DESCRIPTION OF THE SITUATION

Let me give a few examples to illustrate the current situation concerning the participation of women in STEM disciplines in different parts of the world and on different levels.

The report "Europe needs more scientists" (EU, 2004) called for a substantial increase in the percentage of science and technology researchers in the total workforce, and remarked that increasing the number of women entering science and engineering careers would go a long way towards meeting this challenge. The publication "She figures" (EU, 2006) describes patterns of horizontal as well as vertical segregation by sex: Women are under-represented in research generally, and in physical, mathematical and engineering occupations specifically, and women have a lower chance than men of reaching senior levels in R&D. For instance, for the EU-27 countries, around one out of three PhDs earned in 2006 within physical science, mathematics and statistics was earned by a woman, whereas the corresponding figure for computing was around one of five (ibid).

In the USA, men earned a majority of bachelor's degrees awarded in engineering, computer sciences, and physics (81%, 81%, and 79%, respectively) in 2007 (National Science Board, 2010). Among fields with notable increases in the proportion of bachelor's degrees awarded to women were earth, atmospheric, and ocean sciences, agricultural sciences and chemistry, whereas women's share of bachelor's degrees in computer sciences, mathematics, and engineering declined in recent years (ibid).

From the 2008 "Education at a glance" report (OECD, 2008), we learn that the proportion of females among students entering tertiary science studies ranges from less than 25% in Japan, the Netherlands, Switzerland and Chile to more than 35% in Denmark, Iceland, Italy and New Zealand.

In the report "Why so few?", (AAUW, 2010), the American Association of University Women state:

> *By graduation,men outnumber women in nearly every science and engineering field, and in some, such as physics, engineering, and computer science, the difference is dramatic, with women earning only 20 percent of bachelor's degrees. Women's representation in science and engineering declines further at the graduate level and yet again in the transition to the workplace.*

WHY SHOULD WE CARE?

Does it really matter, for science, who performs the research and develops the models? Does it matter who develops the next generation of computers or the newest cancer treatment? Do we believe that women would be happier as scientists than they are as nurses? I will give four reasons why we need to pay continued attention to the recruitment of girls and women to science.

1. *STEM needs women because it needs more people in general.* This argument simply says that it is most efficient to look for recruits where the unexploited potential is greatest.
2. *STEM needs women because women bring new perspectives and ways of working.* This argument assumes that women have potential for engaging in ongoing research and development processes within science and technology, and that the values, interests and experiences they bring into the work are slightly different from those of men, as we will see in the next section. The FP7 Capacities Work Programme for Science in Society (EU, 2007) states that "the pursuit of scientific knowledge and its technical application towards society requires the talent, perspectives and insight that an increasing diversity in the research workforce will ensure. Therefore, a balanced representation of women and men at all levels in research projects is encouraged". Schiebinger (2008) provides examples of how taking gender into account has yielded new research results and sparked creativity, opening new avenues for future research. In order to create a sustainable and knowledge-based economy in an equitable society, expertise in science and technology is needed, and the

participation of both women and men is desirable. Thus, this argument goes that *science needs women* in order to develop in new ways.

3. *Women need STEM in order to influence their own life and the development of the world.* This is related to the above argument, but focus here is on women's empowerment to shape the world and the everyday life that they themselves and their children will experience. This could be related to ensuring that technology development and research priorities serve the interests of both genders. It could also be to let women partake in the wonders of the scientific and technological world – for enriching their lives and contributing to their individual development.
4. *Everyone (including women) should have a real, not only a formal, free choice of education*. By this I mean that the norms, stereotypes and expectations girls meet should allow for a role for women in STEM. Today, stereotypic views of scientists are still prevalent and fit poorly with the ideals that are held up for young women by contemporary culture. Girls will not have a real freedom of choice of education before these mental and cultural barriers are reduced.

Bearing these arguments in mind, we now move on to how young people in general, and women in particular, make their educational choices and how science is assessed in the considerations that determine their choice.

A MODEL OF EDUCATIONAL CHOICE. WOMEN'S CONSIDERATIONS

The expectancy-value model

The psychologist Jacquelynne Eccles and her colleagues have, over a period of more than 25 years, built up and refined a model of educational choice, the so-called expectancy-value model (Eccles (Parsons) et al., 1983; Eccles & Wigfield, 2002). Reflecting a complex issue with a multitude of influence factors, the model itself is accordingly rather complex – but in the research projects "Lily" and IRIS, we have found it meaningful to extract and investigate the most central constructs from the model (the ones that are, in Eccles et al.'s flow sheet, closest to the actual choice). In brief, the expectancy-value model states that educational choices are made based on the individual's *expectancy of success* within the field under consideration, and a range of values that she holds and that impinge on the choice. The values are subdivided into *interest/enjoyment value , attainment value, utility value,* and *cost*. For instance, a young woman who considers choosing the advanced calculus course in her junior year at university, asks herself: Am I good enough; will I be able to obtain a good grade? Am I really interested; do I enjoy working with maths problems? Am I a "maths person"; does it suit my identity? Will it help me reach my goals regarding future education, career and material well-being? How much will it cost me in terms of time and effort?

All these considerations are, of course, to some extent inter-related. Furthermore, they are related to other internal and external factors such as age and previous experience, family background, youth culture, zeitgeist and general trends in society, and so on. We are not forgetting that; but let us focus on these for now and see if there are gender differences in some of these constructs that may help us understand the continued low participation of women in STEM. I will draw on international research as well as results form the aforementioned research projects I am currently involved in regarding young pepole's educational choices concerning STEM disciplines. A lot of the examples will come from physics – both because this subject is representative for some of the subjects with the greatest recruitment challenge and gender imbalance, and because it is the subject where I have my own background.

Expectancy of success

In the Eccles model, expectancy of success is closely related to Bandura's *self-efficacy beliefs* (see e.g. Bandura, 1997; Bandura, Barbaranelli, Caprara, & Pastorelli, 2001).Numerous research reports have shown that girls have lower self efficacy than boys within STEM disciplines (Barnes, McInerney, & Marsh, 2005; Cavallo, Potter, & Rozman, 2004; Lyons, 2006). Häussler & Hoffmann (2000) found that for German pupils, young men's physics-related self concept was higher than their general school-related self concept, whereas the opposite was true for young women. Findings from our own research show that Norwegian girls who have chosen non-compulsory science in upper-secondary school express lower self-efficacy in science and mathematics than boys who have made the same choice. Boys agree more than girls that they learn easily in the subjects and are better at them than most other students. Girls agree more that they worry about not being good enough at the subjects (Bøe, 2010).

Zeldin et al. (2008) and Zeldin and Pajares (2000) found differences in the ways women and men develop their self efficacy related to STEM education and careers: Whereas men's self efficacy arises most strongly from actual (perceived) achievements in STEM-related tasks, women rely more heavily on interaction with others to build their self efficacy. This observation points to the importance of role models and significant others for women's choices. Moreover, Häussler & Hoffmann (2000) found that physics-related self-concept was a strong predictor of interest in physics as a school subject – thus emphasising the interaction between expectancy of success and value considerations related to educational choice. Jacobs et al.(1998) found that actual science performance was a predictor for choice of a physical science profession for young women, even after controlling for factors like family support, science-mathematics-related activities, interest in physical science, and overall grades.

Parents and teachers play a significant role for students' self-perception and expectancy of success in maths and science, thereby also influencing future educational choices (Hazari, Sonnert, Sadler, & Shanahan, 2010). A respondent in the Norwegian "Lily" survey (Schreiner et al., 2010) wrote that "My 8th grade maths teacher 'discovered' me (…) and since then I've been hooked".

Interest/enjoyment value

Eccles and Wigfield (2002) say that their interest-enjoyment value is measured like *intrinsic motivation* (Ryan & Deci, 2000), Csikszentmihalyi's (in Eccles & Wigfield, 2002) *flow*, and Renninger, Hidi and Krapp's (in Eccles & Wigfield, 2002) and Schiefele's (1999) *interest*.

What is it, then, that students find interesting and intrinsically rewarding in science? A number of interest studies in science education show that girls' and boys' interests are *different* (Cerini, Murray, & Reiss, 2003; Osborne & Collins, 2000, 2001; Scantlebury & Baker, 2007). On a general level, girls express stronger interest in issues to do with human health and well-being, whereas boys are more interested in things to do with e.g. technology and physics. A likely reason why boys develop stronger interests in science (particularly the physical sciences) than girls is that they have more childhood experiences involving science and technology (Hazari, Sadler, & Tai, 2008; Jones, Howe, & Rua, 2000; Sjøberg, 2000).

The ROSE survey investigated this question through a questionnaire to 15-year-olds in a range of countries. They found that the interests of girls differed markedly from those of boys in most countries. Whereas boys favoured "dramatic" topics like explosions and technology, girls were more interested in how to take care of the body, how to care for animals, in aesthetic topics like the rainbow and in questions of the paranormal, in why we dream at night, etc (Schreiner, 2006). We may note the tendency of young men to be concerned with the subject itself, whereas young women are interested in topics which may help them in their relations to themselves and to other people. This tendency of young women to be more preoccupied with using their STEM insight in social settings was also noted by Angell et al. (2004) for physics students. Along similar lines, Osborne & Collins (2001) found that British 16-year-olds (especially young women) emphasised the importance of science for explaining things to other people.

Also worth noting in this context is that girls appear to have other criteria than boys for feeling that they understand the subject matter. Stadler, Duit & Benke (2000) claimed that boys and girls hold different notions of what it means to understand physics: Girls think they understand a concept only if they can put it into a broader world view, whereas boys appear to view physics as valuable in itself and are satisfied if there is internal coherence among the physics concepts learned. Osborne & Collins (2001) found that girls expressed a desire to know *why* things happened in science (the causal question) rather than simply learning only *what* happened (the ontological question).

Stokking (2000) found that most physics students in the Netherlands would like a stronger orientation of the subject towards the phenomena of daily life and of the instructional approaches towards active participation. Labudde et al. (2000) suggested that such changes would be effective for improving girls' experience of physics and therefore might increase their likelihood of choosing a science career. Häussler & Hoffmann (2000) claimed that physics as it is taught in the majority of physics courses does not take into account students' interests, and they found that an interest-driven and context-rich physics curriculum was superior to the traditional physics curriculum and that it also resulted in an improved physics-related self-concept, particularly among girls.

Our own data from Norway (Schreiner et al., 2010) show that interest is among the most important reasons expressed by students for choosing a STEM higher education and that this interest may be related to positive school experiences (good teachers), exposure to popular science in the form of television programmes and magazines, and support and encouragement from family members. Again, girls evaluate the influence of *persons* on their choice as stronger than boys do.

Attainment value

Attainment value refers to how important it is for a person to succeed with a task to fulfil personal needs (Eccles, 1994). Completing a science education may be important to a person because it makes her feel happy and proud of herself (affective goals), or because she seeks the stimulation of overcoming challenges and working creatively (cognitive goals). Participating (and succeeding) in certain tasks may also serve to confirm important aspects of a person's identity.

Schreiner & Sjøberg (2007), arguing from a sociological perspective, point to the pre-eminence that contemporary society gives to the individual and claim that modern youth evaluate education against how it may contribute to their self-development. Illeris et al. argue that the traditional question 'What do you want to be when you grow up?' today addresses a more far-reaching issue than before: '*Who* do you want to be when you grow up?' (Illeris, Katznelson, Simonsen, & Ulriksen, 2002).

The "Lily" data shows that self realization is maybe the most prominent aim that beginning STEM students in Norway have for their education and career (Schreiner et al., 2010). All students, regardless of gender and strand of education, put top priority on "developing myself" and "developing my talents and abilities". However, what each individual means by "developing her/himself, may vary – and this variation shows clear gender differences along the well-known lines described above, with women seeking more "person-oriented" and idealistic values and men being relatively more concerned with technology development, leadership and management.

STEM subjects (at least the mathematical-physical disciplines) have an image - be it well-deserved or not - of being demanding, hard, masculine, traditional, decontextualised, theoretical and abstract rather than connected to societal development and human well-being (Aikenhead, 2007; Angell et al., 2004; Carlone, 2003; Osborne & Collins, 2001). Masnick et al. (2010) found that American high school and college students considered scientific professions to be less creative and less people-oriented than other popular career choices. Many students see school science as uninteresting and irrelevant to their lives (Tytler, Osborne, Williams, Tytler, & Clark, 2008), as authoritarian and abstract, and with little room for search for personal meaning (Sjøberg, 2002). This image of the STEM sector is held up against young people's (young women's) priorities and aspirations (as described above), and if it does not appear to meet their image of who they want to be, they will choose *not* to pursue an education and career in STEM.

As we have seen, a crucial question is whether young people (and women in particular) see STEM subjects as worth pursuing and STEM students and professionals as someone they can identify with or admire. Bennett and Hogarth (2009) reported that students in the 11-16 age range expressed a sense of science being important in general terms, although not having much appeal for individual students. Hannover and Kessels (2004) and Taconis and Kessels (2009) used self-to-prototype matching theory to investigate 9th-grade students' self-image and found that the students saw typical peers who preferred science subjects as less attractive, creative, socially competent etc, but more intelligent and motivated, than peers who preferred other subjects. Thus, their image of the typical science student was that of a hard-working and smart but rather boring and clumsy person (slightly paraphrased). Maybe not surprisingly, most of the students in the survey conceived of themselves as being less similar to the science prototype and more similar to the humanities prototype. Taconis & Kessels (2009) pointed to the mismatch between science culture and most students' self-image and identity to explain why few students choose to study science.

Brickhouse and colleagues (2000; 2001) have especially studied the relation between girls' identities and their experiences in school science, and argue that identity formation is essential to understanding science learning (Brickhouse, 2001). A school science or STEM career identity is unattractive to many girls. In their study of Australian year 10 students, Lyons and Quinn (2010) found that girls were especially likely to attribute a non-science choice to not being able to see themselves as scientists. They recommended that efforts should be made to better inform girls about the range of possibilities available to women in science careers. Blickenstaff (2005) also points to lack of role models as one possible reason for women's underrepresentation in science.

Persons may be important in young people's identity formation and educational choice process. Research on the effect of STEM recruitment initiatives indicates that what often makes an impression on potential STEM applicants is the personal meeting with students, teachers or professionals involved in the field (Jensen & Henriksen, 2010). Even persons without a background in STEM can serve important functions as "significant others" in the educational choice process (Sjaastad, 2010). A parent or sibling can "hold up a mirror" and help the adolescent see herself more clearly, help her identify her own strengths and articulate her values and goals, and possibly bring her attention to the wide spectrum of possibilities (including those within STEM) for a person with her interests and priorities. A STEM student in the "Lily" study (Schreiner et al., 2010) wrote: "*Grandmother has meant a lot for the kind of person I have become and has helped me set my goals, wishes and dreams for my life*". In our data material we also see indications that these personal meetings are particularly influential for girls. Baker and Leary (1995) found that "the girls with the strongest commitment to scientific careers learned to love science through the love of a parent or grandparent involved in science". Hasse and colleagues (Hasse, Sinding, & Trentemøller, 2008) found that a majority of Danish, female physicists in their sample hade been inspired to pursue a physics career by their father.

Utility value

Utility value concerns how helpful a certain task or educational choice is in reaching personal goals, such as career goals. Options that have utility value are extrinsically motivated (Ryan & Deci, 2000).

In upper secondary school, STEM subjects are often chosen for their utility value or for strategic reasons since these subjects (mathematics and physics in particular) have a “gate keeping” function for entry into prestigious higher education programmes such as medicine and many branches of engineering science. These subjects may therefore have utility value for many reasons: they can serve as qualifications for specific plans for higher education; they can raise a student’s general qualification level for university admission, and they can help in keeping many options open as long as possible. It is therefore not surprising that utility for future career often emerges an important reason for choosing these subjects in upper secondary school (Angell et al., 2004; Hutchinson, Stagg, & Bentley, 2009; Lyons, 2006; Osborne & Collins, 2001). More short-term goals also give utility value, for instance wanting to take the same course as a friend (Eccles & Wigfield, 2002).

In higher education, choosing a STEM programme for its utility value would mean that one chooses STEM because one believes it will give some kind of benefit that is not related to the intrinsic value or attainment value of the STEM education itself. This could for instance be that a STEM education was regarded as the best way to a secure job or a high income, that it was considered necessary in order to get a job in a dynamic environment or with a lot of travelling, etc. In most Western societies, it appears relatively unlikely that concerns such as these would be a strong driving force for most students choosing STEM higher education. On the contrary, STEM subjects, because of their high perceived cost (see below), are unlikely to be regarded as an “easy” way to good jobs or other benefits.

Hazari et al. (2010) use the term "outcome expectations" for values that students seek in a future occupation, such as for instance high wages, people-oriented work, etc, and they point out that there are great gender differences in these values, such that boys, more than girls, want jobs where they control others, that are easy, make them famous, give them high pay and status, and involve inventing new things etc. This is largely in line with our Norwegian results as described above, where girls aim at more "people-oriented" work whereas boys aim at technology development. Thus, given the image of science and scientists described above, girls are less likely than boys to see STEM education as the best way to reach their goals.

Cost

Relative cost refers to the negative aspects related to one activity or educational choice compared to other options. It could for example be the time and effort that is required to do well in maths compared to social science. It could be fear of failing maths, or fear of disappointing parents. Relative cost also includes lost opportunities from choosing one education over another.

STEM subjects on all levels are generally perceived as having a high cost. This is largely related to their reputation of being hard and work-intensive (Angell et al., 2004; Carlone, 2003; Osborne & Collins, 2001; Tytler et al., 2008). For students choosing science and mathematics in upper secondary school mainly for utility reasons (to get into medical school, for instance), the cost may also be considerable in terms of having to put up with a subject they find uninteresting, unattractive and ill matched to their identities.
Especially girls and women appear to perceive the costs of pursuing STEM subjects and careers to be high (Angell et al., 2004; Carlone, 2003; Warrington & Younger, 2000). Our "Lily" data also show this tendency. On an open question about the reasons why they believe

few young people (and women in particular) choose a higher education within STEM, our first-year STEM student respondents had the perceived degree of difficulty of these subjects as one of the most frequently mentioned reasons.

Summing up gender differences in values and considerations related to educational choice

As we have seen from the above sections summing up research in the framework of the Eccles model, there are gender differences in young people's considerations within all important elements of the model. Girls have lower self efficacy and perceive a higher cost associated with studying science; they identify less closely with the disciplines and the scientists associated with them; they have different interests and different expectations for their understanding within science than do boys, and they do not, to the same extent as boys, see science as a means of attaining extrinsic goals and expectations. Each of these insights carries with it possible lines of action to influence girls' considerations related to science careers and increase the participation of women in STEM. I will return to this point later.

It should be remembered that although the above description of educational choice centers around the considerations students make prior to the actual choice, the experiences, values and attitudes on which they build their choice stem from a far earlier age. We know that childhood and adolescence experiences, both in and outside of school, are important predictors of educational choice and that for the sciences, girls' disenchantment often starts from an early age (Osborne et al., 2009).

A PERSPECTIVE ON CULTURAL DIFFERENCES IN WOMEN'S PARTICIPATION IN SCIENCE

A slightly different approach to understanding the under-representation of women in science may be found in the EU-supported project UPGEM (Understanding Puzzles in the Gendered European Map). This project looked at the difference (in terms of numbers, experiences and outlook) between female researchers (from PhD students and on) in physics in five European countries and described how the career paths of female physicists are conditioned by cultural patterns both within the discipline and in society at large. For instance, the UPGEM researchers compared women in physics in Italy and Denmark and noted that Italy has a higher proportion of female physicists, and also a higher proportion of women who stay on in research after having children. The reasons they suggested for this difference included (Hasse & Trentemøller, 2008):

- *Different paths from school into higher education*: In Italy, there is an obvious path from classical (language/arts/humanities) school backgrounds into natural sciences, whereas this path does not exist in Denmark. In Denmark, according to these researchers, physics students and professionals consider themselves as a particularly clever and theoretically apt breed of people, largely removed from the hurdle of daily and political life. It is unthinkable for a student with a language or social science background from upper secondary school (as many girls have) to enter into physics studies at a university. In Italy, on the other hand, it is the students (including many females) who come from a classical languages background who are considered the most "brainy" people and who see it as a natural path to continue into university studies of for instance science or technology.

- *"Class societies" and "gender societies":* Italy is a "class society" where social background is more determining for a person's choices than gender; thus, it is experienced as natural and appropriate for a woman from the right background to go into physics, whereas Denmark is a "gender society" where individuals orient themselves after what is considered natural or appropriate to do for a person of his/her gender (and physics is, as we know, a "male discipline").

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- *Different family patterns*: Although Denmark has much stronger official support for families with children (daycare centres, maternity leave), the responsibility for children and family is still in practice borne by women and is a matter of private negotiation in each family. In Italy, the extended family (most notably the grandparents) have a much more active and important role, facilitating the career of young female physics professionals.

- *Workplace cultures:* The UPGEM project has described different prototypical workplace cultures in physics departments and noted that what they term the "caretaker culture", where physicists work closely together as a team, is more predominant in Italy, whereas the so-called "Hercules culture", where researchers compete individually for research funding and honor, dominates in Denmark. The "caretaker culture" appears to be better matched with women's preferences and may thus be one explanation for the difference in female participation between the two countries.

Again, we see that each of these findings or perspectives carries with it possible means of influencing the considerations that make many women turn away from science – although the science education community's influence over general culture as well as workplace culture is, of course, limited.

HOW TO INCREASE THE PARTICIPATION OF WOMEN IN SCIENCE AND TECHNOLOGY

Nature or nurture?

Our look at the research results concerning important factors contributing to educational choices has shown that there are gender differences in every one of these factors. Moreover, we have seen that science workplace cultures, as well as general (national) culture, shape women's participation and persistence in scientific fields.

Could it be that these gender differences in priorities, so persistent over time and geographical regions, spring from genetic differences, for instance in mathematical aptitude, between men and women? If that is the case, it might change our view of what may be fruitful in terms of changing the pattern of "gendered" choices through recruitment efforts and curriculum innovations. I will not go into this question in any depth in this paper, but only cite two recent research reports of relevance. First, Ceci et al. (2009), discussing sociocultural and biological considerations relating to women's underrepresentation in science, concluded that:

> *The evidence indicates that women's preferences, potentially representing both free and constrained choices, constitute the most powerful explanatory factor; a secondary factor is performance on gatekeeper tests, most likely resulting from sociocultural rather than biological causes (Ceci et al., 2009).*

Moreover, research indicates that to the extent that gender differences in maths and science achievement are observed, they are small in effect size and often represent an overlap of around 90 % in the score distributions of male and female students (Hyde & Linn, 2006). Gender therefore represents a very poor sorting criterion for which individuals should be encouraged to pursue a STEM education and career.

Based on findings such as these, I think we can safely continue to look for ways in which cultural conditions may be changed in order to invite more women into science and technology. The findings presented in the previous sections give us clues concerning how to proceed with this challenge.

Self efficacy

Low self efficacy appears to be preventing many girls from choosing (and staying in) STEM. Interventions aimed at increasing the self efficacy of girls (for instance through mentoring projects) might be expected to be effective for recruiting more women to STEM. Our research group in Oslo is currently studying mentoring relationships in the Norwegian recruitment project *Enter* (2010), where university science and maths students give mathematics training to groups of secondary school students, and we hope to be able to say something about which aspects of such a project appear to have an effect – on both the self efficacy and the values that young students associate with science and mathematics.

Values

To increase the *interest/enjoyment value* that girls experience in their meetings with science and technology (notably through school science), providing *meaningful contexts* appears crucial. Girls' general interests and values – of human health and well-being for instance – can easily be used as entry points into a range of subject areas such as for instance nuclear physics (connecting to cancer treatment). Also, the work forms employed in science instruction both in schools and higher education need to include active participation, collaborative learning, and attention to connections between theoretical understanding and real-world contexts if girls are going to develop a sense of ownership and positive interest in the field.

The *cost* of pursuing a science education and career is still perceived as high – and probably deservedly so. We will not do anyone a favor by enticing young people into these fields on false premises. Rather, we might get inspiration from the Swedish campaign *Intize* (2010), where mathematics students function as mentors to high school students with slogans such as the joy of "exercising your maths muscles" – with the message that mathematics *is* challenging, but that this very fact contributes to making it attractive to pursue – in much the same way as sports-interested youth may be motivated to exercise in order to beat their own (or someone else's) previous records.

Raising the *attainment value* of the science subjects – that is, girls' evaluation of how important it is for them to be a part of the scientific community and how this fits with their view of themselves – is obviously harder than changing school science, since it is related to general societal trends. Until the science and technology subjects acquire an image which allows for and includes more diverse aims, values and outlooks – a greater diversity - many girls will probably continue to see science as an area that is ill matched to their view of themselves and who they want to be. Female role models are often advocated as a solution to this problem; however, the effect of role models on young people's educational choice process appears hard to document, as noted by for instance Hazari et al. (2010).

Personal meetings and "significant others"

What does appear to have an effect, is the personal meeting with a mentor or even a so-called "significant other" (parent, sibling, teacher, youth club leader,…) who knows the adolescent and is willing to help her clarify her goals and her personal strengths and interests (Sjaastad, 2010). This is particularly important for girls, who rely more than boys on personal relations and advice. (Baker & Leary, 1995; Schreiner et al., 2010). Again; mentoring programs appear to be a good way of providing such support. Moreover, a possible strategy might be to make parents, teachers and others with whom young people relate, aware of the important role they can play in helping the youngsters make their educational choice, and to alert these "significant others" to how science and technology actually may accommodate a range of different types of work and people with a range of values and aims. Teachers are in a unique position to communicate such information to young people.

Workplace culture

As we saw from the UPGEM project (Hasse & Trentemøller, 2008), workplace culture may be an important factor shaping the retention of women in STEM careers, and is likely to "trickle down" and contribute to shaping the image of these fields, thereby affecting recruitment as well. Thus, attention to workplace culture appears necessary in order to understand and address the issue of women's participation. Hazari et al. (2010, p. 17) remark:

> *Anyone who has a physics background or has worked with physicists knows that there is truth to the claim that the physics culture promotes "physics for the sake of physics." The benefit of this cultural standard is that those who end up participating usually love the theoretical basis of what they do. This internal drive is important for motivating the large amount of dedication needed to become a cutting-edge physicist who pushes the boundaries of our knowledge. However, there is a fundamental imbalance in this norm because mainly those who come from backgrounds with the luxury of affording knowledge-based motivations will opt into physics. Others who have additional motivations, like socio-economic concerns, will need to have a passion for physics above and beyond the norm in order to disregard such concerns and opt into physics.*
> *[…]*
> *Perhaps if the physics community promoted and supported more balanced motivations, physics would be more successful in attracting members of under-represented groups.[..] [O]ther areas, such as the humanities, do not carry the stereotype that you have to give up your "life" to be successful.*

Nothing new under the sun?

As the reader may have noticed, most of these suggestions are by no means new – they have been forwarded (in various forms) through several decades. However, since the situation is still far from satisfactory and recruitment of both women and men to STEM is still a pressing issue, we have to continue to focus on the proposed solutions and to implement them and evaluate what appears to work in practice. As we as researchers progress in our understanding of the experiences, values and considerations that lead up to young people's choice of education, we will be able to elaborate on the proposed solutions and to have a more fruitful dialogue with stakeholders who can contribute to implementing changes.

Note also that many of the proposed solutions meant to increase the participation of women may work equally well to recruit and retain more diverse groups of young men (Labudde et al., 2000). I know of no evidence from research that implementing the changes that are assumed to increase women's participation, would function to turn men away. To the contrary, the proposed measures are likely to increase the diversity of personalities that may feel attracted to science and to scientific and technological careers so that the future workforce within these fields will not only be greater in numbers and more even in gender distribution, but will generally include a greater multitude and variety of outlooks, experiences and aims. My contention is that this will be possible without compromising the basic requirements of all high-quality science education and scientific research and development, such as critical reflection, mathematical rigor (where appropriate), careful examination, attention to evidence, etc.

Finally, we must not forget that although I have described a range of instances where women – on average – prioritize slightly differently form men, the diversity of outlooks among women, and among men, is very great so that gender in itself is a poor predictor of, for instance, interest in chemistry or self efficacy in mathematics. There are, of course, women whose priorities resemble the typically male outlook rather than the female – and men who prioritize more like the average female.

SUMMARY AND CONCLUSION: REVISITING CURIE AND BEAUVOIR

Thinking back to the story of Marie Curie at the outset of this paper, I think we may say that female pioneer as she was, she entered the discipline of physics largely on the premises of men (how else could she?). Although she displayed classical "feminine" traits for instance through her engagement in using radiation in the treatment of wounded soldiers during World War I, there are also indications that she was one of those women who are in many ways comfortable with the "physics culture". For instance, she is quoted as having said that "In science we must be interested in things, not in persons" (http://en.wikiquote.org/wiki/Marie_Curie). This was 100 years ago, at a time when the female participation in science and technology was only a fraction of what it is today. Today, as we have seen, science and technology (and society) might benefit from a greater diversity than just "white, middle-aged men of both sexes"; we need more diverse attitudes, outlooks and ideas.

Remember also Beauvoir's description of how women were construed to have no drive or urge to develop their faculties to the fullest and to transgress boundaries (Pilardi, 1999). Results that I have presented here, show that at least on a superficial level, this is not the case: Both young women and men, across a range of academic disciplines, have self realisation and personal development on top of their list of motivation factors for pursuing higher education. However, it appears that far more men than women see *science* as a means of fulfilling that ambition. The STEM field is in many ways still a man's culture, and it appears to be a far more natural choice for a young man to go into science than it is for his sister.

We need to do away with the assumption that only one set of values and goals, only one kind of (inborn) disposition, defines what a scientist is and should be. Paraphrasing Beauvoir and focusing on the positive possibilities, we might say that "One is not born a scientist, but becomes one". There is no single determining factor to define who is suitable to go into science; the skills needed in order to make valuable contributions to science and technology can be acquired by a far greater number (and variety) of persons than those who have up to now dominated the scientific and technological enterprises.

As science educators we should communicate as best we can that a range of different values, goals and experiences can fruitfully be brought into the scientific and technological enterprise, sparking new ideas and new applications of knowledge, for the benefit of the individual (who experiences self development and fulfilment) and for society.

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TRENDS IN ICT AND MULTIMEDIA BASED EDUCATION

Janez Bešter

Univerza v Ljubljani, Fakulteta za elektrotehniko

janez.bester@fe.uni-lj.si

Marko Papić

Univerza v Ljubljani, Fakulteta za elektrotehniko

marko.papic@ltfe.org

Andrej Gregorc

Univerza v Ljubljani, Fakulteta za elektrotehniko

andrej.gregorc@ltfe.org

Rok Žurbi

Univerza v Ljubljani, Fakulteta za elektrotehniko

rok.zurbi@ltfe.org

ABSTRACT

Amount of information and resulting knowledge needed for competitive inclusion of any individual or institution into knowledge society is rising constantly. At the same time, life span of knowledge is decreasing. Lifelong learning is playing a very important role in modern times as almost any individual, regardless of age or profession is required to constantly gain new knowledge. Changes and adaptations to traditional learning methods and educational systems are needed in order to eliminate the divide between those that have the knowledge needed and those that don't.

Changes and adaptations of educational systems are very much related to ICT (Information and Communication Technologies). ICT can act as a tool that fosters these changes, aldo changes in educational systems should be implemented because of completely different (non ICT related) reasons. Supporting ICT and Multimedia are in many cases mature enough to be systematically introduced into educational process. It is not only about making education more appealing, but also about increasing effectiveness in education. Use of ICT is oriented towards constructive learning, whereas in many cases learning goals can be achieved easier and faster. Use of ICT in education also decreases digital divide and increases competitiveness of work force.

In this article all aspects of systematic ICT introduction into education are presented. Necessary organizational changes as well as modern pedagogical approaches, enabled by the use of ICT, are described. The article focuses on the changing role of educational practitioners and presents complete ICT and multimedia supported educational system, ranging from technologies, virtual and real environments as well as to content and support needed. The components of the system are supported with case examples. Important issues that prevent necessary changes of educational systems on the bigger scale are described and commented.

Keywords: *technology supported learning, life-long education, multimedia, e-learning 2.0, web 2.0, virtual community, national educational portal, user generated content, e-portfolio, e-course, virtual classroom, knowledge building, knowledge management, game based learning*

EDUCATIONAL SYSTEM TODAY AND TOMORROW

Existing formal educational system was first established in the mid 19th century. As industrial society was under development, the system delivered only basic knowledge and skills. It was mostly oriented towards forming the working force. Knowledge needed at the work place included only repetitive activities and didn't change in the life time of an individual.

Since then, the basic concept of the formal educational system didn't change much. In the 20th century it was only expanding in quantity of knowledge transferred from educational practitioners to learners, however it was still designed according to the principle "one size fits all". All learners were treated as the same, given same content and same didactical methods.

Today we are becoming more and more aware, that individuals have different talents, characters and different interests related to our work and education. Formal educational system has not adapted, formal curricula still consists of mostly repetitive knowledge/skills and does not adapt to the needs of the modern society, meaning to the needs of the industry environment and of the future work places on any positions. Thus, the credibility gap is expanding as expectations and demands of the employers vary from the actual knowledge and skills acquired by the current and future employees.

Another issue, which needs to be tackled is the existing knowledge assessment system, which is in many cases out of date, as it only checks repetition abilities of known facts up to the certain degree (in percentage) that should be sufficient for professional qualification.

One of the main findings of the 2009 ONLINE EDUCA conference, the worlds main event in ICT supported education was that existing educational systems in Europe are in many cases not capable to offer the "vision of the world" but only to present "the world as it is".

The statements introduced above call for the introduction of changes and adaptations of formal educational systems. Pedagogical approaches and content provided should be adapted to the specific needs and expectations of individual learners. Plurality should be encouraged and all who dare and are able to think different from the uniform majority should have incentives from the educational system. It is therefore crucial to identify and distinguish "ability to memorize and learn", the skill that can be learned, from "talent", the exceptional characteristics of individuals. Adaptations of formal educational systems call for organizational changes, which should foster individuality. At the same time they should be able to respond quickly to transformations of the modern society, which appart from the individuality stress the importance of the collaborative or collective learning and work on all fields.

INNOVATIVE PEDAGOGICAL APPROACHES AND ICT (TEACHERS DON'T TEACH, THEY MODERATE!)

Adaptations of the educational systems depend on the introduction of the innovative pedagogical approaches which are in most cases based on knowledge construction. Knowledge construction can be performed through different forms of collaborative and project work that end with specific result (product, document, presentation, etc).

Unlike in the past, ICT tools and services that can be used in the learning process enable widespread introduction of such methods and represent good motivational lever. Reduction of time needed to acquire learning goals is another positive aspect of using ICT in the learning process. ICT enables simple creation of constructive learning process results and products as user generated content. Another advantage of ICT use is the capability of simple, time and space independent sharing of results with other learners.

Innovative pedagogical approaches can be performed through lessons in which lesson specific content is represented through multimedia, whereas ICT acts as the learning tool. One example of such lessons can be game based learning (GBL). Digital games have great motivational potential. Apart of using most up-to-date ICT equipment, high quality educational games consist of interesting interactive and multimedia content that immerses the player into the virtual world of the game. Various types of existing games (e.g. multiplayer, repetitive, role playing, adventure) can be effectively adapted and used in the educational process to support constructive learning methods.

Constructive learning methods that can be performed with the use of modern ICT terminal equipment (e.g. electronic boards, tablet PC, smart readers and phones), didactical software, multimedia interactive content and knowledge assessment software enable knowledge building through constructing and sharing learning process results. These methods also enable acquisition of soft skills, not necessary related to the content of learning, such as working and collaborating in teams, selecting relevant information, decision making and last but not least becoming familiar with various techniques of learning.

Constructive learning methods require the change of the learning practitioners role. In this concept teachers don't teach. They moderate and support the learning process. This change reflects in the preparation as well as performance of each lesson. In most occasions learning practitioners are required to be more innovative, to spend more time for preparation and less time for repetitive activities. In order to implement adaptations and changes described, the whole educational system should be adapted. The work load of learning practitioners should be reevaluated, administrative and other non pedagogical activities activities should be simplified. Most important, teachers should be properly supported to address new pedagogical challenges and demands of the modern society.

EDUCATIONAL SYSTEM AND ICT (E-SCHOOL IS NOT A VIRTUAL SCHOOL!)

ICT can act as the supportive tool in order to foster implementation of adaptations described in the previous chapters. When describing ICT supported education, two layers need to be addressed:

- learning practitioners layer
- learning participants layer

Learning practitioners need to be trained and supported to use ICT effectively. ICT tools, services and content to be used in their classrooms should be treated like any other accessory teachers use within their lessons. ICT for learning participants on the other hand should be embedded or seamlessly integrated in their learning process. For this purpose set of web based tools should be available for them to use in or outside of the classrooms. Following chapters describe training and e-competency challenges as well as four necessary components of ICT introduction into educational system:

1. Multimedia learning content
2. Web based virtual learning environment
3. Technical and didactical support

4. Cooperation with research and development sector and academia

E-COMPETENCY REQUIREMENTS

Learning practitioners need to be properly trained in order to use ICT tools, content and services effectively. Acquisition of ICT competences for teachers differs from regular digital literacy trainings offered to the rest of the population. For teachers, it is important to know how to use technologies, services and solutions introduced into learning process. ICT is just the tool, only when it is used properly, added value to the learning process can be achieved.

Teachers training should be therefore performed in two levels. The first level is independent of the subject area and is very much similar for all learning practitioners. It needs to be performed modularly, through blended learning (live and by distance). Duration of the training should be one or two semesters depending on the types and extent of modules chosen by the teachers.

The main aim of the first level of training is to enable teachers to perform their lessons through selected innovative learning method with the use of ICT.

Advanced or second level of teachers training should be related to the use of specific ICT tools in their subject area. These trainings are commonly performed in shorter practical workshops with the focus on use cases and adaptations of the chosen ICT tool and selected learning method.

When competency requirements of majority of learning practitioners are not met, the success of ICT introduction into the learning process is limited to early adopters, enthusiasts and progressive teachers. There are cases where governments invest substantial amount of financial resources into ICT in education without getting satisfying results. This is due to the fact that they invest in provisioning infrastructure and technologies and are not giving enough focus on teachers competences. In long term this may even cause negative consequences. Instead of decreasing digital divide among learning participants, it may grow bigger as it depends on individual learning practitioners and their personal interests in using ICT in their learning process.

Digital literacy of learning participants is equally important. It has different focus as it needs to be related to the soft skills needed to select, evaluate and extract relevant information, acquired from digital and other approved or non approved information sources.

Multimedia Learning Content

Multimedia learning content represents an alternative to existing content in the educational process. It is appropriate to develop digital content in cases when it can be effectively presented visually and when interactivity that has added value can be implemented. In these cases, multimedia content may help in better understanding. It may also open new aspects of the topic learned, which couldn’t be presented in the classical textbooks. Enabling learners to interact with the content is equally important. Finally, multimedia content is available from anywhere and anytime, whereas the printing and distribution costs are much lower compared to classical learning material.

There are three basic types of multimedia content:

- Professional e-schoolbooks (e-courses, covering all subject areas)

- Specific multimedia content used with specific ICT tool and for specific subject category (e.g. electronic boards)
- User generated content (created by learning practitioners and learning participants)

All three types of multimedia content need to be supported. E-schoolbooks should be made professionally [http.//www.e-gradiva.si/]. Evaluation and validation processes should be defined and included. Specific multimedia content exceeds the scope of e-schoolbooks, however, their existence is crucial in order to use the available infrastructure and ICT terminals effectively [http://qfk.ltfe.org/]. Their introduction should be directly related to the introduction of specific ICT equipment. No ICT equipment, tools, terminals or similar should be introduced without clear vision of provisioning adapted multimedia content.

The concept of user generated content has proven to be one of the main drivers of Web 2.0 evolution in the past. As end users were able to develop and share content simply by themselves, Internet and belonging services started to be used actively, reaching almost any user anywhere in the world, regardless of their age or occupation, wherever the infrastructure was available. Therefore it is expected to be one of the dissemination drivers in the ICT supported education as well. User generated content should be supported by set of simple web based content development tools available to learning practitioners as well as learning participants[http://coome.ltfe.org/].

WEB BASED VIRTUAL LEARNING ENVIRONMENT

Virtual learning environment should consist of set of distributed web based applications that can be described from the users perspective as two main entities:

1. National Educational Portal (applications enabling access to data, information, content and knowledge
2. Learning Environment (applications enabling performance of the learning process)

National educational portal consists of set of vertical portals, provided by public educational administration, educational industry or independent initiatives, enabling community establishment (learning practitioners and participants, principals, parents, policy makers, industry, etc.), access to multimedia content (learning objects) and access to different administrative activities. One example of vertical portals could be video educational portal, enabling upload, editing and access to video learning objects to be used in the learning process [http://www.sitv.tv]]. Another example would be electronic board portal, enabling access to content and support for the use of electronic boards.

National educational portal should provide access to technical and pedagogical support and environment for connecting all stakeholders (pedagogues, parents and policy makers). Another important component is smart and personalized search engine, providing access to national repository of learning objects as well as validated repositories around the world.

Learning environment consists of set distributed applications enabling learning process to be conducted over the web. The key activities supported should be content development, virtual classrooms, set of collaboration and communication tools, electronic knowledge assessment (testing), e-portfolio building, progress tracking and finally constant evaluation of the activities performed [http://www.e-cho.org].

TECHNICAL AND DIDACTICAL SUPPORT

Apart form the content related issues and learning process supporting tools, there is another crucial component of successful ICT introduction into learning process that targets learning practitioners. The appropriate technical but especially support should be provided systematically through well defined organizational model that includes consulting to learning practitioners. This model should include competent institutions, ranging from educational industry, consulting companies, expert individuals, as well as schools themselves. The model should promote institutional cooperation, based on clearly defined projects with learning practitioners. Evaluation aspects and constant quality assessment should also be integrated.

Support can be conducted over the communication and collaboration tools within the national educational portal or through set of consultations. However, best results are achieved when performance of ICT supported lessons by learning practitioners is monitored by experienced consultants in the form of mini projects.

COOPERATION WITH RESEARCH AND DEVELOPMENT SECTOR AND ACADEMIA

The field of ICT use in education is very dynamic. It changes and adapts constantly as new technologies are introduced and methodologies of their use are discovered. It is virtually impossible for educational system to follow trends and new findings, without systematic cooperation with academia and interdisciplinary R&D sector. This cooperation needs to be defined systematically, through set of pilot projects introducing new methods of ICT use in education. The focus should be on evaluation and dissemination, so that best cases would be introduced into the ICT supported learning system and performed on the wide scale.

CONCLUSION

ICT tools, services and solutions are mature enough to be introduced into the learning process systematically and used by other learning practitioners than enthusiast only. The reasons for expansion of ICT use are numerous, apart form making the learning process more appealing, ICT may support easier achievement of learning goals, increase in digital literacy and consequently in the competitiveness of the modern work force.

ICT introduction affects various existing business processes in education. Later should not adapt because of ICT but due to non ICT related reasons, explained in the article. The process of introduction of modern technologies is alive and never really ends. It needs evaluation, monitoring and constant adaptation. It is comprehensive and interdisciplinary. As such it needs systematic approach, enough human as well as financial resources available.

Public education administration and policy makers need to jump on this rapid train of technology development and become part of the leading edge. They shouldn’t enforce solutions, concepts and their views, but they should systematically moderate and support innovation in the educational process.

Authors of the article have many years of experience in implementing technologies as well as supportive solutions enabling effective ICT introduction into educational system [http://www.ltfe.org/]. During our previous work with different target groups of users we came to the conclusion that if educational system will not adapt to new, emerging paradigm in education, the parallel structures will be established by learners themselves, leaving teachers and educational system behind and even increasing the existing credibility gap.

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HOW DO STUDENTS PERCEIVE SCIENCE AND TECHNOLOGY?

Svein Sjøberg

University of Oslo, Norway

svein.sjoberg@ils.uio.no

Camilla Schreiner

University of Oslo, Norway

camilla.schreiner@ils.uio.no

ABSTRACT

ROSE is an international comparative study that investigates the diversity of interests, experiences, priorities, hopes and attitudes that children in different countries bring to school or have developed at school. The underlying hope is to stimulate an informed discussion on how to make science education more relevant and meaningful to students in ways that respect gender differences and cultural diversity. We also hope to shed light on how to stimulate interest in S&T-related studies and careers. ROSE has developed, after consultation with science educators from all continents, an instrument that tries to examine the attitudes of 15-year-old students. The ROSE instrument has around 250 single items – simply worded questions or statements requiring responses on a 4-point Likert scale. This enables the use of standard statistical methods like calculations of means and correlations. About 40000 students from 35 countries took part in ROSE, and about 10 PhD students from different countries will base their theses on ROSE data. Schreiner & Sjřberg (2004) report fully on the project rationale, development and logistics. Additional information, including reports on data collection from the participating countries, is available on the ROSE website. Several comparative articles and international reports have been published and more are planned.

INTRODUCTION

In many highly developed countries, there is a noticeable decline in the recruitment of students to science and technology (S&T) studies. 'Europe needs more scientists' is the title of a report by the High Level Group on Increasing Human Resources for Science and Technology in Europe (EC, 2004). This report examines the condition of S&T in the European Union and pays special attention to the number of people entering S&T education and careers. The title of the report reveals the point: the falling recruitment to S&T studies is seen as a large problem in most European countries. The same tendencies are noted in the USA and in most other countries in the Organisation for Economic Cooperation and Development (OECD).

It is a paradox that the most S&Tdriven economies in the world are experiencing a lack of interest in S&T studies and careers among young people. The economic significance to a country of a high number of skilled scientists and engineers is well accepted. But young people do not choose their studies or careers because it is good for the domestic economy. Instead, they base their choices (when they have such choices) on their own interests, values and priorities. It is obvious that S&T studies and jobs no longer have the appeal in wealthier countries that they had some decades ago.

The lack of interest in S&T in schools and further studies is not only a problem for the economy, but also a threat to democracy, as most decisions in modern societies are highly dependent on considerations that involve weighing scientific arguments against value judgements. A scientifically illiterate voting population can be easily manipulated by propaganda.

For these reasons, it is important to understand the S&T-related attitudes, priorities and interests of the young generation: this is what the Relevance of Science Education (ROSE) study aims to do.

POSITIVE PERCEPTIONS OF S&T IN SOCIETY

When we note the lack of interest in S&T studies and careers in some countries, the first and most obvious hypothesis might be that young people in such countries have negative or hostile attitudes towards S&T. Such assertions are often voiced in public debates. S&T is blamed for many of the evils of modern societies, like pollution, destruction of the environment, overuse of natural resources and even modern warfare and conflicts. Do young people really base their attitudes on such assumptions?

Several questions in the ROSE study shed light on this question. The results indicate that there is no general hostility against S&T among young people, neither in rich nor poor countries; generally, positive responses were received to statements such as:

- Science and technology are important for society
- A country needs science and technology to become developed
- Science and technology will find cures to diseases such as HIV/AIDS and cancer
- Thanks to science and technology, there will be greater opportunities for future generations
- Science and technology make our lives healthier, easier and more comfortable
- New technologies will make work more interesting
- The benefits of science are greater than the harmful effects it could have
- Science and technology will help to eradicate poverty and famine in the world
- Science and technology are the cause of the environmental problems.

"Science and technology are important for society."

"I like school science better than most other subjects."

Figure 1

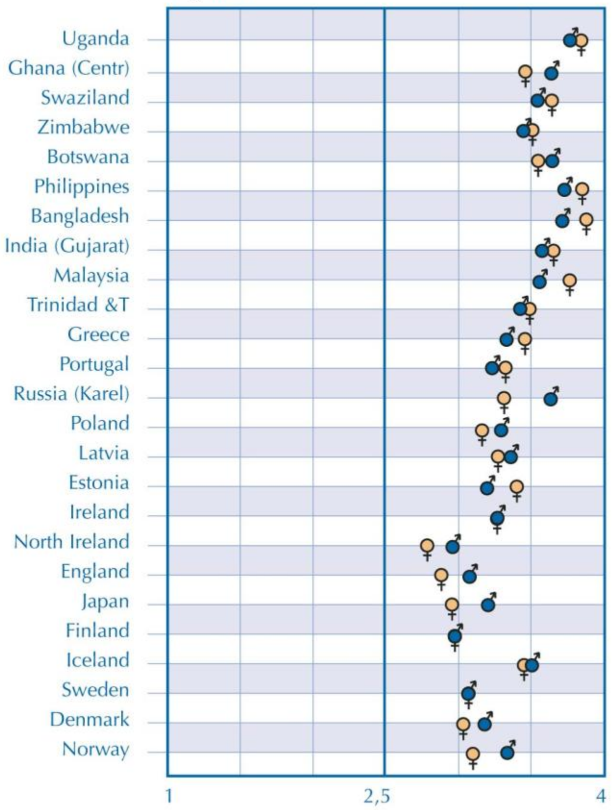
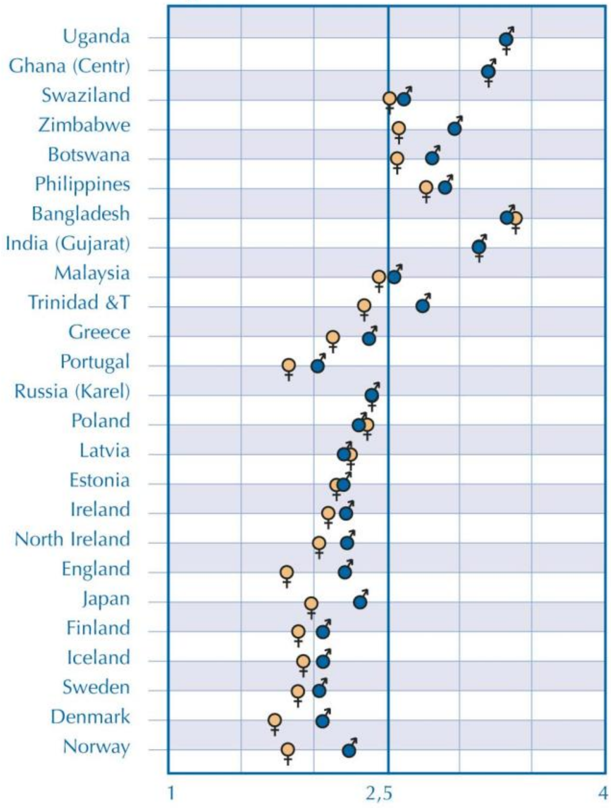


Figure 2



ROSE data showing mean values for girls (open female symbol) and boys (filled male symbol). The scale goes from 1 (disagree) to 4 (agree). Hence, 2.5 is a neutral response, marked with a vertical line. For some countries, only certain regions took part: in Ghana, only the Central region; in Spain, only the Balearic Islands; in Russia, only Karelia. India is represented by the region of Gujarat

Most students (aged 14-16) in most countries agree to statements like those listed above, although there areinteresting differences between nations and between girls and boys. In general, boys are more positive (or less sceptical?) than girls about S&T, and pupils in developing countries are more positive than pupils in richer countries. But it is important to note that the overall attitude towards S&T is positive.

As illustrated in Figure 1, girls and boys in all countries show pronounced agreement with the statement "Science and technology are important for society". Children in developing countries agree more strongly. Gender differences are rather small.

PROBLEMATIC ATTITUDES TO S&T IN SCHOOLS

Although students in all countries of the role of S&T in society, the attitudes to S&T in schools are more mixed.

As Figure 2 demonstrates, there are large differences between how much students in different parts of the world like school science. In general, students in developing countries like school science very much, whereas students in richer parts of the world are more negative. We also note large gender differences: in some countries, girls dislike school science more strongly than do boys. ROSE also includes a series of questions about how students have benefited from school science, but space restrictions prevent us from detailing these here.

BACKGROUND

ROSE (Relevance of Science Education)

ROSE is an international comparative study that investigates the diversity of interests, experiences, priorities, hopes and attitudes that children in different countries bring to school or have developed at school. The underlying hope is to stimulate an informed discussion on how to make science education more relevant and meaningful to students in ways that respect gender differences and cultural diversity. We also hope to shed light on how to stimulate interest in S&T-related studies and careers. ROSE has developed, after consultation with science educators from all continents, an instrument that tries to examine the attitudes of 15-year-old students. The ROSE instrument has around 250 single items – simply worded questions or statements requiring responses on a 4-point Likert scale. This enables the use of standard statistical methods like calculations of means and correlations. About 40000 students from 35 countries took part in ROSE, and about 10 PhD students from different countries will base their theses on ROSE data. Schreiner & Sjøberg (2004) report fully on the project rationale, development and logistics. Additional information, including reports on data collection from the participating countries, is available on the ROSE website[w1]. Several comparative articles and international reports have been published and more are planned.

RELUCTANCE TO ENTER S&T CAREERS

Many ROSE items ask young people about the plans and visions they have for the future. Here, we only give the responses to two simple questions: whether the student wants to become a scientist (Figure 3), and whether the student wants to work in technology (Figure 4).

As illustrated in Figure 3, there are dramatic differences between the responses from students in rich and in developing countries. In developing countries, students have a strong desire to become scientists, whereas students in most OECD countries are reluctant, with average responses of less than 2 on the 4-point scale. We also note the strong gender pattern, particularly in wealthier OECD countries. In many of these countries, the average response for girls is around 1.5, indicating that most of them strongly reject the idea of becoming scientists.

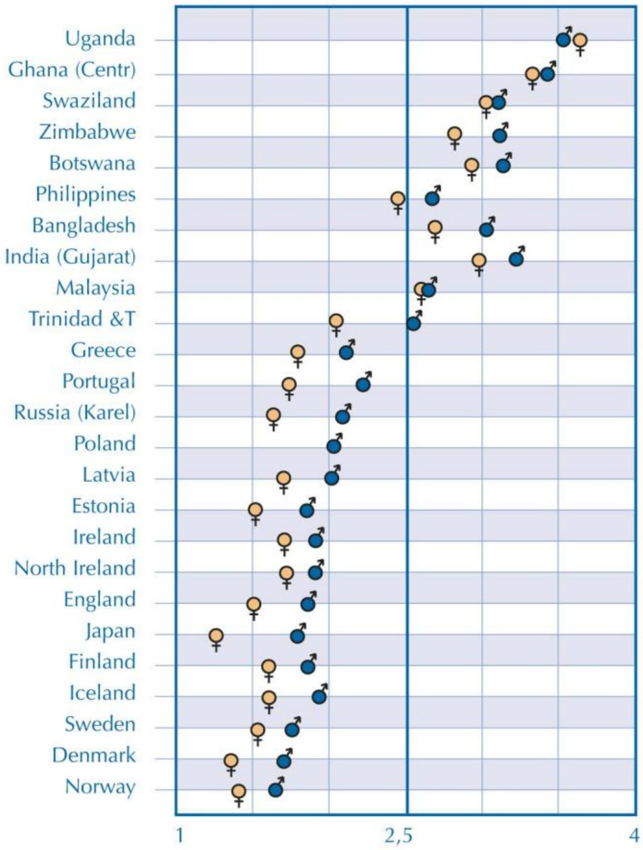
In Figure 4, we see a similar, but even stronger, pattern: working in technology seems to have a much stronger appeal in developing countries than in rich countries. In many wealthy countries, the average response from boys is close to the neutral line (2.5), but the responses from girls are strongly negative. We also note that in Japan, girls and boys are more negative towards working with technology than are students in any other country.

CONCLUSIONS

This short article gives an indication of the data and information emerging from the ROSE study. We have only presented summary statistics for four of the 250 items; more details and advanced analysis will be available on our websitew1. The first PhD based on ROSE data has recently been presented (Schreiner, 2006), detailing the analysis of the interests young children have in different topics in science and technology. Based on this analysis, a typology of students is suggested.

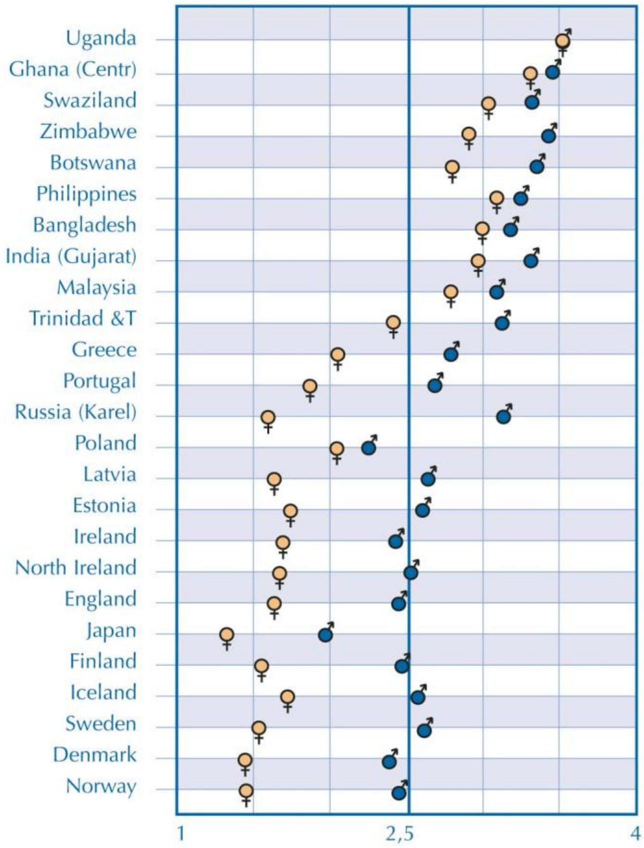
"I would like to become a scientist."

Figure 3



"I would like to get a job in technology."

Figure 4



ROSE data showing mean values for girls (open female symbol) and boys (filled male symbol). The scale goes from 1 (disagree) to 4 (agree). Hence, 2.5 is a neutral response, marked with a vertical line. For some countries, only certain regions took part: in Ghana, only the Central region; in Spain, only the Balearic Islands; in Russia, only Karelia. India is represented by the region of Gujarat

Through ROSE, we hope to stimulate an informed discussion on important aspects of S&T and its role in society and in education. Researchers from many cultures are involved in the research and discussions about issues of common concern. International cooperation, networking and capacity building are also intrinsically important. Our hope is that S&T education will be an instrument not only to promote material development and well-being, but also to address basic human values.

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SCIENTIFIC PAPERS

TEACHING STRATEGY FOR HUMAN REPRODUCTION AND SEX EDUCATION

Abrougui Mondher

ISEFC -UVT

abrouguimondher@yahoo.fr

Makhlouf Naima

ISEFC -UVT

makhlouf.naima@yahoo.fr

ABDELLI Sami

ISEFC -UVT

abdelli_sami@yahoo.fr

MOUELHI Lassaad

ISEFC -UVT

mouelhilassaad@yahoo.fr

***ISEFC – UVT** : Institut Supérieur de l'Education et de la Formation Continue*

Université Virtuel de Tunisie, - Tunisia

ABSTRACT

This communication introduces one innovative strategy for overcoming scientific, moral and cultural constraints and difficulties of human reproduction and sexuality teaching. To do this, we have implemented sequences and workshops for pupils of the first level of secondary school and educators, including teachers and inspectors of primary and secondary schools and specialists of biology didactics). Sequences of sensitization helped lead the questioning on human reproduction and sexuality education. All questions have been boosted by the establishment of a specific website, structured as a wiki interface. This website takes into account didactics dimensions. This approach met the expectations of pupils and helped to enrich scientific knowledge of the reproductive system, while developing an approach to health promotion and sex education in its broadest sense. The strategy used is an example of a teaching that shows how pupils, teachers, inspectors and didacticians can interact in a complementary fashion.

KEYWORDS: *Sex education and Human reproduction, Didactics, Wiki, Conceptions, Health promotion.*

1. INTRODUCTION

Sex education is a term used to describe education in a broad way about human sexual anatomy, sexual reproduction, sexual intercourse, reproductive health, emotional relations, reproductive rights and responsibilities, abstinence, contraception, and other aspects of human sexual behavior. Common avenues for sex education are parents or caregivers, school programs, and public health campaigns. Sexuality concerns the human being as a whole; it has a multidimensional impact (Pelege & Picod, 2006). Sexuality in many countries, particularly countries characterized by religious faith remains a taboo subject. Yet, this human dimension raises many questions for social scientists which may be interesting to consider in a process of education and more particularly to health education (Berger et al. 2006; Abdelli & Abrougui, 2005, 2006; Abrougui et al. 2006, 2008).

2. METHODOLOGY

2.1 Workshop outreach and data collection

Three types of workshops were organized:
First, workshops for pupils at the first level of secondary school have been carried out during sequences in health clubs. Teachers' interventions were very brief. Pupils were asked to participate to a WebQuest and to submit their result on a wiki which had been specially designed for this purpose.

Second, workshops for a group of pupils and teachers were held in sequences in health clubs. These workshops explained how to distribute the questionnaire and collect responses.

Finally, workshops for a group of trainers (teachers and inspectors of primary and secondary schools and specialists in didactic of biology) were held during sequences of courses and workshops. Trainers were asked to consult students' responses to questionnaires group them according to a classification grid and respond according to three criteria. All their actions are directly integrated on a website specially designed for this purpose. The workshop aimed to describe approaches to improve collaborative learning. We gave advice how to conduct a learning session combining Wiki and an appropriate WebQuest.

2.2. Webquest and wiki

A website, including a WebQuest and a wiki, have been specially designed for the purpose of this research. A WebQuest is an inquiry-oriented lesson format in which most or all the information that learners work with comes from the web. The model was developed by Bernie Dodge at San Diego State University in 1995 with early input from SDSU/Pacific Bell Fellow Tom March, the Educational Technology staff at San Diego Unified School District, and waves of participants each summer at the Teach the Teachers Consortium (retrieved from http://webquest.org/index.php, Dodge (1995),)

Since those beginning days, tens of thousands of teachers have embraced WebQuests as a way to make good use of the internet while engaging their pupils and students in the kinds of thinking that the 21st century requires. The model has spread around the world, with particular enthusiasm in many countries. Since it was first developed, the WebQuest model has been incorporated into hundreds of education courses around the world. WebQuests provide an authentic, technology-rich environment for problem solving, information processing, and collaboration. This inquiry-based approach to learning makes excellent use of internet-based resources by involving students in a wide range of activities. WebQuests are designed to use learners' time well, to focus on using information rather than looking for it, and to support learners' thinking at the levels of analysis, synthesis, and evaluation as pupils or students work collaboratively to solve a real world problem or complete a task. Each team member assumes roles that best represent some aspect of reality. Pupils or students engage in problem-solving investigations to construct their own knowledge.

What makes WebQuests so appealing is that they provide structure and guidance for both students and teachers. All WebQuests should include the same basic elements to achieve clarity of purpose and efficiency (maximum use of time and computers). According to Dodge (1995), the basic elements or critical attributes are listed as follows:

1. **Introduction:** The introduction sets the stage and provides some background information ;
2. **Task:** The task should be interesting and doable ;
3. **Information Resources:** This element includes such resources as web documents, experts available via e-mail or conferencing, searchable databases on the net, and books and other documents physically available in the learner's environment ;

4. **The Process:** This element clearly describes the steps for the learner to accomplish the task ;
5. **Guidance:** This step describes how to organize the information acquired by using guiding questions, or directions to complete organizational frameworks such as timelines, concept maps, or cause-and-effect diagrams ;
6. **Conclusion/Evaluation:** This step brings closure to the activity, reminds the learner what he has learned and encourages him to extend the experience into other domains.

Some non-critical attributes of WebQuests include group activities, motivational elements such as role-playing, a possible scenario to work within, or simulated e-mail persons to communicate with. WebQuests can be designed within a single discipline or they can be interdisciplinary (Abrougui et al., 2008). Our research team has been working on extending the original idea of WebQuests using a didactic approach. This paper presents a use of WebQuests for teaching human reproduction and sex education.

A wiki is a type of website such as Wikipedia that lets anyone create and edit its pages, enabling fast and easy collaboration (Leuf & Cunningham, 2001). A wiki enables documents to be written collaboratively in a simple markup language using a web browser. A single page in a wiki website is referred to as a ”wiki page“, whiles the entire collection of pages, which are usually well interconnected by hyperlinks, is "the wiki". A wiki is essentially a database for creating, browsing, and searching through information. A wiki promotes meaningful topic associations between different pages by making page link creation almost intuitively easy and showing whether an intended target page exists or not. In a wiki, people can write pages and edit content together. This can facilitate abuse of the system. Private wiki servers require user authentication to edit pages, and sometimes even to read them.

For the WebQuest and the wiki, in didaquest.org website, we used a wiki powered by **MediaWiki**, copyright (C) 2001-2009, version 1.15.1, under the terms of the GNU General Public License

2.2. Target audience

With the objective of non-formal education, a WebQuest has been established and was administered in a health club. This activity has mobilized the participation of a number of teachers, students and others (summarized in Table 1):

- Two **B**iology **T**eachers (**TB**), head of the health club and guiding the implementation of this WebQuest by the pupils. Those teachers are responsible for clarification, explanation and guidance of the various activities carried out.
- 39 pupils in the ninth level of Basic Education College of Tunisia (last year of the first level of Tunisian secondary school). These pupils were all "**P**upils **L**eaders of **W**ebQuest” (**PLW**) because they have participated, through various missions, activities that have enabled the evolution of this WebQuest by referencing or data collection. These pupils were divided into two classes of health club:
  - The class C1, composed of 23 pupils. They were assisted by a Biology teacher (SVT teacher). They have participated, not anonymously, in this WebQuest ;
  - The class C2, consisting of 16 pupils. They were assisted by a SVT teacher. They participated anonymously in this webquest ;
- **U**nquantifiable number of **P**eople (**UP**). These are the people who contributed to enrich the information obtained through the development of this WebQuest by their questions, comments or even by their explorations of topics and activities available to bet. During this research, the UP is mainly composed mostly of pupils from the same Tunisian school or belonging to a relationship of 21 **PLW** ;
- **E**valuators of the **W**ebQuest (**EW**). To assess the relevance of this WebQuest an assessment category was made available to all persons wishing to make an assessment. Among the **EW**, 10 inspectors in training were asked to evaluate this WebQuest.

Table 1: Target audience by gender and assigned activities.

<table>
<tr><th>Target audience</th><th>Status</th><th>Gender</th><th colspan="2">No:</th><th>Age</th><th>Specification</th></tr>
<tr><td rowspan="4">Public from health club</td><td rowspan="2">Tunisian pupils</td><td>Female</td><td>21</td><td rowspan="2">39</td><td>17-14</td><td rowspan="2">PLW (Pupils Leaders of Webquest)</td></tr>
<tr><td>Male</td><td>18</td><td>17-14</td></tr>
<tr><td rowspan="2">Tunisian teacher</td><td>Female</td><td colspan="2">1</td><td>34</td><td rowspan="2">TB (Teacher of Biology)</td></tr>
<tr><td>Male</td><td colspan="2">1</td><td>43</td></tr>
<tr><td rowspan="5">Other public outside the health club</td><td>Tunisian pupils</td><td>Female & Male</td><td colspan="3">Unidentified</td><td rowspan="2">UP (Unidentified People)</td></tr>
<tr><td colspan="2">Unidentified people</td><td colspan="3">Unidentified</td></tr>
<tr><td rowspan="2">Tunisian Inspectors in Training</td><td>Female</td><td>1</td><td rowspan="3">10</td><td rowspan="2">34-49</td><td rowspan="3">EW (Evaluators of the Webquest)</td></tr>
<tr><td>Male</td><td>9</td></tr>
<tr><td>Specialists in Didactic of Biology</td><td>Male</td><td>3</td><td>39-44</td></tr>
</table>

2.3. WebQuest: Sex education in a Arab-Muslim context

In this research, to facilitated teaching human reproduction and sex education, we have adopted a WebQuests “L'éducation à la sexualité dans un contexte arabo-musulman”(Sex education in a Arab-Muslim context). This WeQuest extending the original idea of webquests using didactic approach. The basic elements or critical attributes are divided in 7 sections listed as follow (Table 2):

1- Title and presentation section; 2- Teacher section; 3- Pupils section; 4- Production section; 5- Disciplinary section; 6- Authors section; 7- More information. section

Each section corresponds to a specific public (Table 2). For more clarifications about this sections consult the Webquest at didaquest.org website:
http://www.didaquest.org/wiki/Portail:Sexualite

2.3.1. Webquest task « mission »

For convenience, and to make it interesting and feasible, the mission has been formulated as follows:
“Your Tunisian friends have many questions about sexuality:
- Either they do not ask for several reasons.
- Or, they ask, but do not always find the answers to their questions.
If you want to help and inform your friends you will have the task of selecting and achieving, with or for them, two of the five following activities:

1. *Complete, with a survey, List A (List of “Questions about sexuality”) And give some answers,*
2. *Complete, with a survey, the List B (List of “Ideas about sexuality”: Quiz, answer true or false)*
3. *Show the different dimensions related to sexuality education and explain the importance of this education*
4. *Add questions or ideas to the lists A and B (This activity was done by all students)*
5. *Make a list of organizations and associations who can help with any difficulties or problems.*

For more details a web link inside this mission is given for pupil’s guidance. This guidance describes procedures and steps for a successful implementation of the mission and explains how to organize the information acquired.

Table 2: Sections of WebQuests : "L'éducation à la sexualité dans un contexte arabo-musulman"(Sex education in a Arab-Muslim context)

WEBQUEST: SEX EDUCATION IN A CONTEXT ARAB-MUSLIM	
WebQuest Overview	
WEBQUEST: SEX EDUCATION IN A CONTEXT ARAB-MUSLIM TEACHER PARTY	
• Introduction • Student information • Process • Resources	• Evaluation Criteria • Conclusions • Acknowledgments
STUDENT PARTY	
• Introduction • Task • Process • Links and Resources	• Evaluation • Conclusions • Acknowledgments
AUTHORS WEBQUEST	
• List and information about the authors of this WebQuest	• Date of preparation
PRODUCTIONS	
• Produced documents • Media products	• Produced activities • Other productions
DISCIPLINARY FIELD	
• List of Disciplines • Multidisciplinary	• Interdisciplinarity • Transdisciplinarity
MORE INFO	
• List of Participants • General Remarks	• WebQuest Evaluation • Other Information

2.3.2. WebQuest explanation of mission elements

***- List A** : Questions about sexuality*
The questionnaire is anonymous. It is very simple because it is formed by a single question. In this questionnaire, pupils are asked to submit their questions in relation to the theme of "human reproduction and sex education". Their responses could either be delivered to a group of pupils responsible for referencing or data collection or to their teachers, either directly deposited on a website, including a WebQuest and a wiki, specially designed for this purpose. It was stated that the results of their questionnaire responses could be viewed directly on the same website. *They can, also, give some answers to chosen questions.*

***List B** : List of "Ideas about sexuality":*
This list is used to reference or to test ideas or assertions concerning reproduction and human sexuality. To do this, pupils will specify, via a click, if these allegations are true or false. From their choices and their answers they can assess their position relative to some misconceptions, prejudices or stereotypes.

2.4. Treatment of wiki and WebQuest

2.4.1. Treatment of questionnaire data

All responses are filed on a website, a wiki site "didaquest.org", in the List A *"Questions about sexuality"*. The questions raised by pupils are treated according to a classification grid and according to criteria explanatory (2.4.1.1. & 2.4.1.2).

2.4.1.1. Grid classification of pupils' questions

The pupils' questions were grouped according to the following dimensions: Biology; Sexual and reproductive health; Psycho-emotional; Socio-cultural (Table 3)

Table 3: Sample of grids for categorizing dimensions related to Human reproduction and sex education

Biology							
Anatomy	Physiology	Endocrinology	Neurology	Embryology	Genetic	Immunology	Ecology
Sexual and Reproductive Health							
Biomedical aspects	Promotional aspects	Individual aspects	Social aspects				
Psycho-emotional							
Individual	Relational	Fears and concerns	Addictions				
Socio-cultural							
Policy / Legislation	Economy	Culture / Customs / Myth	Religion	Ethics / Morality			

2.4.1.2. Criteria for clarification of pupils' questions

The explanation of pupils' questions by trainers should be made by one of the three following criteria:
- Explanation by direct responses
- Explanation to avoid confusion
- Explanation to avoid misconceptions (false conceptions)

2.4.2. Treatment of *"Ideas about sexuality"*

The purpose of the list B "Ideas about sexuality", about the misconceptions, prejudices or stereotypes is threefold. Firstly, it allows several statements to reference that can induce misconceptions. Secondly, it aims to encourage pupils to reflect upon the pertinence of their assertions, following the self-assessment (self-evaluation) of their responses (answer true or false). Finally, it is also possible to quantify pupils' responses and to deduce the number of misconceptions, prejudices or stereotypes. However, in this paper we only take into account the qualitative aspect, the first two points, emphasizing the impact of statements about pupils thinking.

2.4.3. Treatment of consulted pages

Even though this notion goes against Wikimedia privacy policy, in our wiki we have to analyze the user's activities relatively to particular pages. In this purpose we used 4 complementary statistics tools:

- **Mediawiki** Special: SpecialPages: This page contains a list of special pages. Most of the content of these pages is automatically generated. This page contains several statistics special links (Active users, list, User contributions, User group rights, Users, Recent changes and logs, Gallery of new files, New pages, Recent changes, Related changes, Media reports and uploads, Preference statistics, Statistics, System messages, High use pages, Most linked-to categories, Most linked-to files, Most linked-to pages, Pages with the most revisions). Examples of a statistics special page:
- **Mediawiki Special: Statistics:** a page, included in the mediawiki software, in special pages , that reports the current number of articles. Also recorded are the total number of pages overall, the number of edits and edits per page, and the number of registered users and administrators, along with links to other statistics pages.
- **Mediawiki Extension WhoIsWatching** (Version 0.9)**:** This extension provides an interface, at the bottom of every page, to see which of its users are watching particular

pages. Additionally, this extension has an option to allow any user to add any page to any other user's watch list.

- Mediawiki Extension: WhoIsWatchingTabbed (Version 1.3.1)
This extension create a tab "Who's watching this? (X)" where X is the number of users watching the page. When the tab is viewed it will display a grid of users who are watching the page. Each result will display the username, user real name, and page name. Usernames are linked to the same watching page, but will display all pages that the user is watching. Page names are linked to the same page, but will display all users watching that page. This installation will provide access only to administrator group. Viewing the special page will display top watching users and top watched pages defaulted to 10 each but with ability to raise that limit.
- **AWStats** (Version **6.95**): This statistic tool is a free software distributed under the GNU General Public License. AWStats is a powerful and featureful tool that generates advanced web, streaming, ftp or mail server statistics, graphically. This log analyzer works as a CGI or from command line and shows all possible information, in few graphical web pages. It uses a partial information file to be able to process large log files, often and quickly. A log analysis enables AWStats to show the following information:

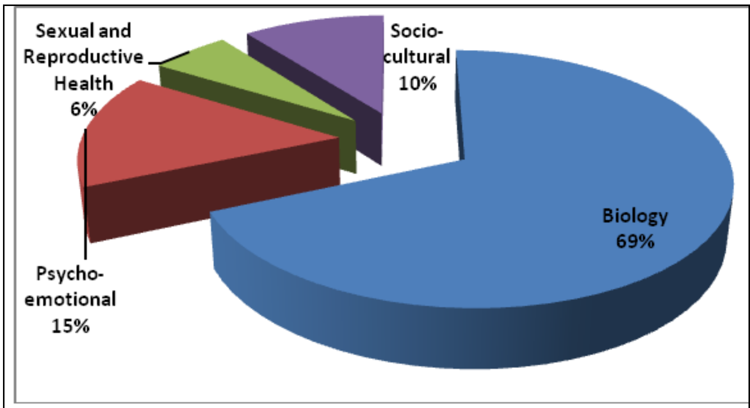
- Number of visits, and number of unique visitors,
- Visits duration and last visits,
- Authenticated users, and last authenticated visits,
- Days of week and rush hours (pages, hits, KB for each hour and day of week),
- Domains/countries of hosts visitors (pages, hits, KB, 269 domains/countries detected, geolocalisation detection),
- Hosts list, last visits and unresolved IP addresses list,
- Most viewed, entry and exit pages,
- Files type,
- Search engines, key phrases and keywords used to find the site or contents about this site (The 115 most famous search engines are detected like Yahoo, Google, Altavista, etc...),
- Number of times the site is "added to favourites bookmarks".
- Other personalized reports based on URL to analyze particular pages, keywords, categories,..

To facilitate the reading of the results, we only present in this communication, the statistics for the categories of the most visited sections, between March 2009 and May 2010 (Rank, Article, page views).

3. RESULTS

The following figures and tables show, following the mission assigned by the WebQuest, the impact on production activities and pupils website consultations:

It is important to note that several dimensions could be treated and viewed by pupils (Figure 1 and 2) .



Human reproduction and sexuality Aspects	**Page views on this website**
Biology	*24166082*
Psycho-emotional	*5325551*
Sexual and Reproductive Health	*2058586*
Socio-cultural	*3683232*

Figure 1: Graphical representation of wiki consultation pages related to reproduction and sexuality (Cumulative website consultation by Ip, between March 2009 and May 2010).

All dimensions have been consulted extensively with a minimum of 250,000 consultations. In these consultations:

- A great importance is given to biological aspects, particularly in anatomy and physiology (Figure 2).
- The dimension on health, although the least consulted, allows pupils to reflect on the dimensions of biomedical problems, while emphasizing the aspects relating to health promotion.
- The psychological dimension is viewed significantly, especially the aspects of "fears and concerns" and the relational dimension.
- The socio-cultural aspects show that pupils are both interested in issues relating to laws but also to religion and ethics. The relative "Cultural / Customs / Myth" aspects are the most consulted, which could contribute to destabilize certain prejudices or misconceptions.

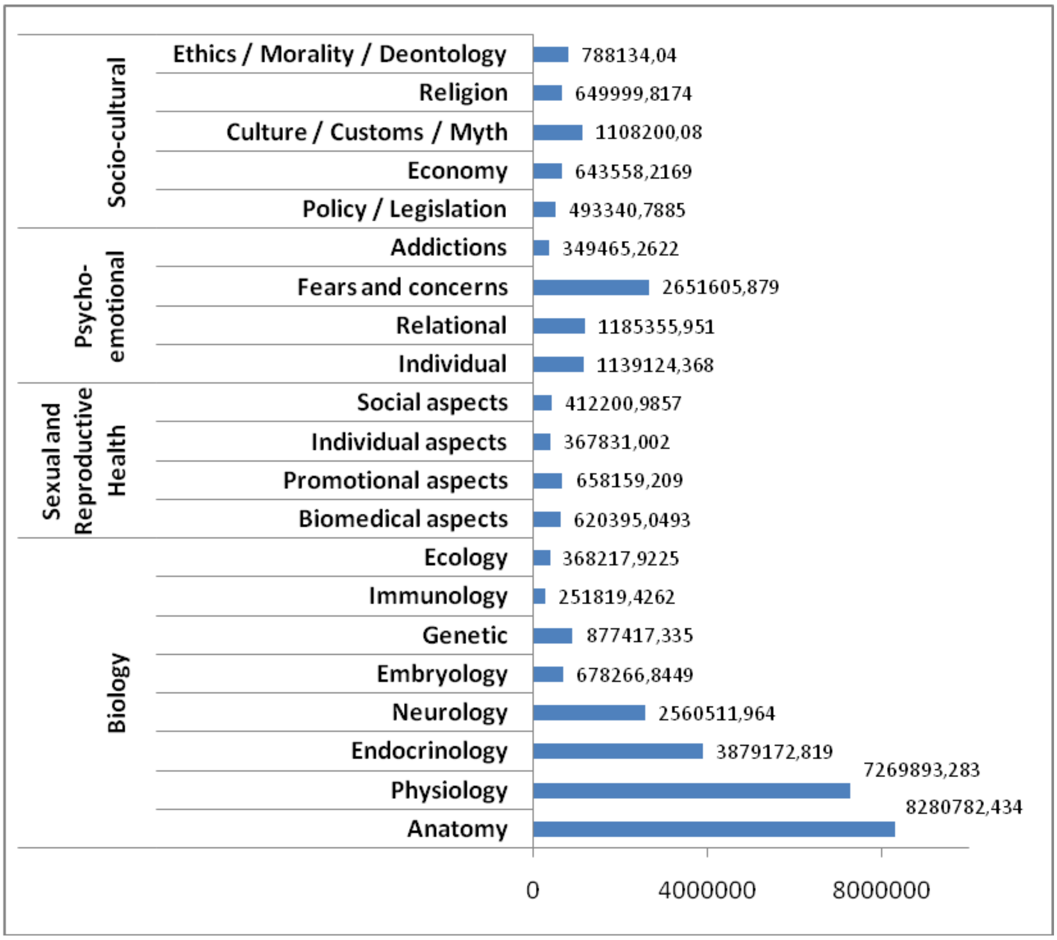


Figure 2: Details of graphical representation of wiki consultation pages related to reproduction and sexuality (Cumulative website consultation by Ip, between March 2009 and May 2010).

Figure 3 clarifies the expectations of pupils. Virginity seems to be a major concern and the hymen occupies a privileged position. This aspect reflects the influence of social and cultural context Arab-Muslim. It is important to note that expectations concerning sexual life and concerns about birth control are also important and they go beyond the scientific concerns related directly to the genitals and their schedules. It is also important to note that feminine components are most viewed.

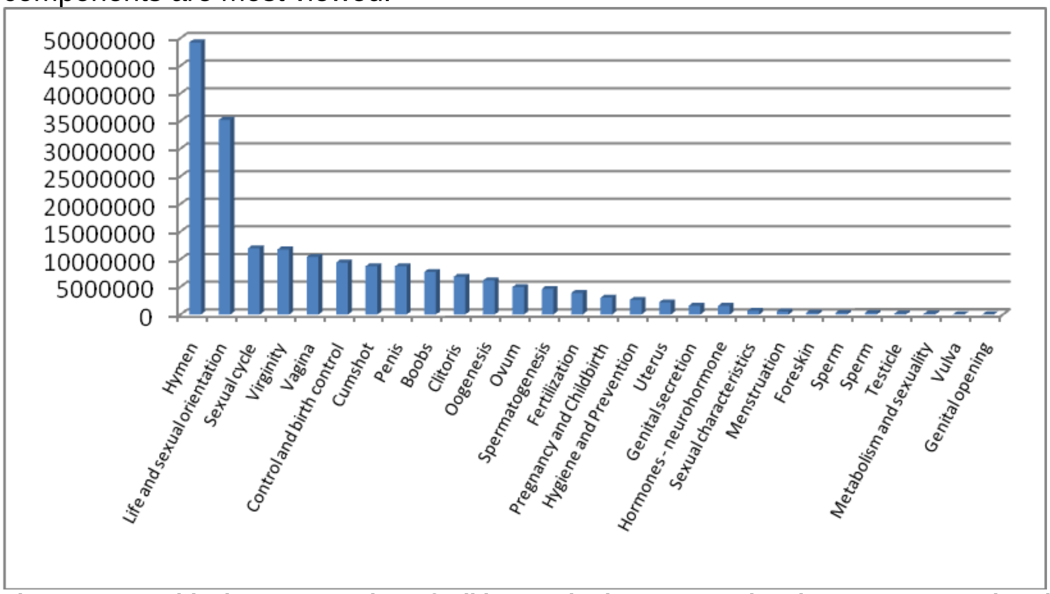


Figure 3 : Graphical representation of wiki consultation pages related to concepts and notions of human reproduction and sexuality. (Cumulative website consultation by Ip, between March 2009 and May 2010).

The section related to “Questions” (List A) and those related to misconceptions (List B) are very informative. Over 1,500 questions were asked (see website Didaquest.org). The results of Figure 4 show the importance of consultation of the questions of pupils and more significantly the importance of interface “true / false questions” (self-evaluation)

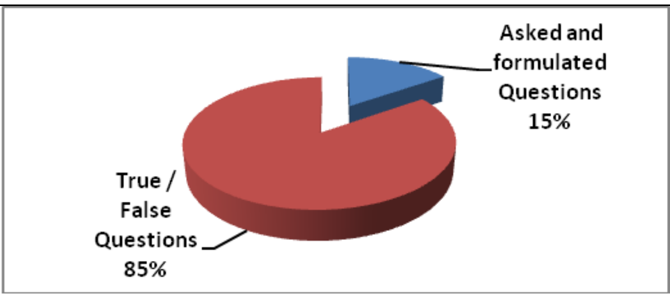
<table>
<tr><th>Human reproduction and sexuality viewed activities</th><th colspan="2">Page views on this website</th></tr>
<tr><td rowspan="2">
</td><td>Asked and formulated Questions (more than 1500 questions asked)</td><td>181436</td></tr>
<tr><td>True / False Questions</td><td>1005172</td></tr>
</table>

Figure 4: Graphical consultation activities "Asked Questions" and "True / False questions. (Cumulative website consultation by Ip, between March 2009 and May 2010).

In the light of expectations and pupils' activities, the pupils and the educators (teachers, inspectors) have been important in structuring expectations and categorizating and explaining questions and ideas. The interests of different stakeholders are summarized in Table 4.

Table 4: Examples of interests of different actors (pupils and educators)

<table>
<tr><td>Inspector’s Participation - This participation has been important in connection with the following:</td></tr>
<tr><td>• Formulation of program from questions and needs of adolescents
• Development of educational strategies on one or more dimensions and proposed activities for the classroom, health clubs or for non-formal educational settings (some techniques: anonymous questions, Metaplan (sticky), group discussion, Brainstorming (brainstorming), variants of the Abacus Regnier, variants of Chinese portrait, burdock (Bardane), photolanguage (photo-expression), ICT (Wiki, WebQuest, simulations, ...)
• Evaluation of contents, documents and websites offered
• Specification of objectives and skills that can be mobilized
• Recommendations for teachers and stakeholders</td></tr>
<tr><td>Teacher Participation - This participation has been important in connection with the following:</td></tr>
<tr><td>• Management of pupils activities (production, debates, ...)
• Mobilization of objectives and skills (see skills list in website)
• Restatement questions of students
• Assess the students' productions
• Consolidation of questions and expectations of students
• Identification of concepts and their grouping
• Enrichment of content, documents and web links
• Followed the development of contents with high expectations
• Development raises questions
• The pupil guidance in taking into account the different biological aspects, and psycho-social issues related to reproduction and sex education.
• Help pupils in the construction of arguments to pass from opinion to thought</td></tr>
<tr><td>Pupil participation - This participation has been important in connection with the following:</td></tr>
<tr><td>• Investigation into the WebQuest (for pupils in health clubs) through the activities and investigations, particularly
- The collection of questions of their fellows
- Reformulation of questions in the form of misconception, or affirmation (correct or not).
• Formulation of expectations through asked questions
• Self-evaluation of their responses regarding their views and more particularly to certain prejudices
• Position in the discussion of “controversial issues”
• Dissemination of the site (autonomously and independently of applications for teachers)</td></tr>
</table>

The strategy used, in conjunction with pupils' expectations, has resulted in the following outcomes:
For pupils -

- To collect a large number of pupils' questions by raising or inhibiting certain taboos
- To identify the interests of pupils, according to two complementary indicators (dimensions classification issues, and frequency of consultation pages).
- To specify explicitly some confusion and pupils' conceptions (misconceptions, prejudices or stereotypes)
- To enrich scientific knowledge of the reproductive system, while developing an approach to health promotion and sex education in its broadest sense.

For educators -

- To provide tools for teachers to provide training, or additional training.
- In coordination with the pupils' activities and results of their products it was possible to optimize the wiki, taking into account the frequency of consultations on dimensions related to sexuality and the referencing of questions and misconceptions.

4. CONCLUSION

Learning effectiveness depends on a large range of parameters. A learner's activity has an important impact on long-term learning and comprehension of difficult concepts (Wilson & Lowry, 2001). Collaboration is also an important parameter for learning efficiency. Collaboration does not work *per se* (Dillenbourg**,** 1999); an appropriate strategy is a key factor for succeeding. This communication describes approaches to improve collaborative learning by presenting how the complementarities of an appropriate WebQuest and a wiki can facilitated learning and teaching of human reproduction and sex education. Combining those two strategies seems to be a powerful tool for constructivist learning environments because it not only facilitates collaboration but also shows how to deal with themes that raise multidimensional questions about scientific, social aspects including taboos. Additionally, this research shows educators how to use digital tools, such as WebQuest and Wikis, in order to create relevant, interactive learning experiences. Finally, this strategy is an example of a teaching strategy that shows how pupils, teachers, inspectors and didacticians can interact in complementary fashion.

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ITALIAN FEMALE AND MALE STUDENTS VIEWS ON SCIENCE AND TECHNOLOGY

Alessandra Allegrini

Observa - Science in Society

iris_nrg@observanet.it

Stefania Crovato

Observa - Science in Society

iris@observanet.it

Giuseppe Pellegrini

University of Padova

giuseppe.pellegrini@unipd.it

1. INTRODUCTION

Traditionally, female are more distant from science then male ones and from the choice of scientific training, in particular in the area of mathematics and physics. Indeed, even today, in all European countries, the educational choices of students reflect a persistent heterogeneity in terms of gender: among the science faculties, while female are more frequently enrolled in medicine, biology, biomedical engineering and mathematics to address educational, the male enrol more often in physics, computer science, mechanical engineering and pure and applied mathematics. Despite an overall growth in numbers of girls in scientific fields over the last thirty years, it is still continuing the so-called "Leaky Pipe phenomenon" (literally, conducted leaky), showing the progressive loss of potential women to high levels of education and careers and technology. This happens despite female students are to graduate sooner and better than their peers, even in science faculties, as documented in various national and international surveys (EC 2009a). The data relating to 2006 show a difference in this regard since 31% of women in degree programs in science and engineering up to 11% of professors at the highest level of scientific responsibility. This difference clearly indicates the gap between men and women even though the comparison between 2002 and 2006 indicates a slight improvement on the status of female (EC 2009b)

Table 1. Proportion of men and women in a typical academic career (Science and Engineer). Students and academic staff. (EU 27) 2002/2006

	% female 2006	% male 2006	% female 2002	% male 2002
ISCED SA Students	31	69	30	70
ISCED SA Graduates	34	66	34	66
ISCED 6 Students (Phd)	36	64	36	64
ISCED 6 Graduates (Phd)	36	64	33	67
Grade C	33	67	29	71
Grade B	22	78	17	83
Grade A	11	89	8	92

Source: European Commission, *She Figures 2009. Statistics and Indicators on Gender Equality in Science*, Luxembourg, Pubblications Office of the European Union, 2009.

In recent years, this phenomenon (a relevant gap in the female training and scientific career) in some way is beginning to affect even the male. There is indeed a comprehensive "scientific vocations crisis" which is shared by students, especially in the fall enrolment in courses to undergraduate physics and mathematics area. At the same time, in the case of male, there is not only an increasing orientation towards the humanities (a typical female orientation), but also a greater interest towards the technical application, unlike female who are still nowadays more interested in the environment and health (EC 2009b).

What contributes to this diverse attitude of students towards science? To answer this question, we must investigate what is the students' imaginary around science in the contemporary world, and the interest that both appear towards science subjects at school and to the scientific career paths to try to understand, finally, what influences their choice of university studies (Arzenton, Nechifor, Pellegrini 2008).

The survey conducted within the ROSE1 project has helped to provide some elements of the social representation of science expressed by boys and girls of 15 years, providing certain assumptions underpinning this diverse male and female attitudes toward science, science subjects and training and scientific careers. In particular, through Rose, it has been possible to identify certain types able to outline the main differences between boys and girls with respect to science in general and science at school in particular.

The research took into account three variables: geographical area, type of school, gender differences. Among these, the gender difference has been the most significant. For this reason we chose to focus on this variable. The survey involved 1445 students attending the second year of high school. We tried to select a homogeneous group of students composed of gender and the kind of study: 53.6% of students are girls, while boys are 46.4%.

The main areas investigated by the research has been:
- the students' interest about science and scientific topics;
- their opinions on science and technology;
- images of science and technology created into the school context;
- the experiences related to science and technology in the school context.

2. METHODS

The Italian wave of ROSE survey was conducted through an interpretative approach oriented to highlight primarily what would emerge from the data. The adoption of this methodology has allowed the development of an analysis able to exploit the environment to the sample, rather than theories or models of interpretation developed by the Public Understanding Studies of Science, the movement of researchers and experts of communication built up from the '70s to give to the public the tools for understanding the science and to teach literacy in different scientific subjects.

It is an approach midway between a quantitative and qualitative study: the theory must be developed from data in order to remain faithful to the data, trying to develop classifications and categories that integrate and explain the data.

This approach is particularly important where you intend to develop a gender analysis because it can leave aside "gender blind" theories, so called "gender neutral" theories, and thus leave room for assumptions and arguments that have a contextual significance. On gender approaches' "contextualism", a vast literature in feminist epistemology is available,

1ROSE: the Relevance of Science Education is an international comparative research project meant to shed light on factors of importance to the learning of science and technology (S&T) – as perceived by the learners, specifically by students towards the end of secondary school (age 15). http://www.ils.uio.no/english/rose/index.html.

that, for reasons of space, we are not going to deepen here. At very large sum, several feminist epistemologies are developed from a shared assumption: the subject of knowledge is not an abstract subject, neutral and universal, but a concrete, embodied, gendered and partial subject. Also the contexts we want to know are not a neutral, but they have systematically a gender dimension that reveals the symbolic and material relations between female and male, and between women and men. For this reason, any theory of knowledge, and any survey taking gender into account, can not develop from abstract theoretical models, neutral and universal, but necessary items from data, quantitative and qualitative, disaggregated by gender, and related to specific contexts under investigation, in which men and women relate2.

3. MAIN RESULTS

Despite the overall decline in enrolments in science, engineering documented in various sources, both domestic and international (Vesentini 1994; Anisn 2003; Eurobarometer 2008), the research showed a high level of trust of students in scientific research, particularly in relation to its contribution to the overall improvement of life. This positive attitude emerged in previous surveys on youth: in those carried out by IARD all of the respondents believe that scientific research has a vital role in ensuring high quality of life, the most recent Eurobarometer detected among Italians levels of trust in science even above the European average. (Eurobarometer 2008)

At the same time, the study of science subjects at school is unattractive and difficult, although its importance is not underestimated. So also is little attraction to the opportunity to pursue a career in research science and technology.

The low attractiveness of the scientific profession may be at least partly explained by comparing the occupational aspirations of new generations with the image of the work of the scientist is more widespread: a work full of creative opportunities and expression of individual qualities but also a work which requires a dedication and an investment so strong as to become almost all-encompassing, imposing the renunciation of the possibility to find satisfaction in other areas of life. Not only the image of the work of the scientist, but also the large image of science is not very positive. Indeed, while there is a high trust in science, particularly in relation to its contribution to the overall improvement of quality of life, the figure of the scientist does not collect, by contrast, extremely positive. This finding introduces a discontinuity with the past, even recently, when on the contrary, scientists enjoyed great credibility and could count on widespread image of neutrality and objectivity.

Moreover, it highlights an apparent contradiction between the lack of willingness to deepen their scientific inclination and the wide use of technologies (mobile phone and computer) widely found in extra-school environment. Although this is only a seeming contradiction considering that the skills required for the use of technological objects, even the most complicated, do not include the knowledge of scientific principles, the different issues addressed by the ROSE research, to which male and female students show greater interest (health, possible risks arising from technological development, sexually transmitted diseases, issues of energy and those relating to environmental protection) largely refer to applied dimension of scientific knowledge.

2 For a discussion of the contextualism in feminist epistemology, see for example: Alcoff and Potter, 1993; Harding and Hintikka, 1983; Harding, 1986; 1991; Longino, 1990; Vassallo, 2003.

4. ATTITUDE TOWARD SCIENCE AND ACHIEVEMENT MOTIVATION PROFILES OF MALE AND FEMALE

Starting from the analysis of data collected, we identified the following profiles: the omnivore, the disinterested, the environmentalist, the healthful. For each of these profiles we set out the most significant characteristics in relation to: overall interest to all the thematic areas proposed in the survey, further work on environmental issues, science at school and confidence in scientific research.

1) The omnivorous: is a student who tends to be more interested than the average in any thematic area concerned. In relation to future work this student shows a strong propensity for creativity and independence, suggesting self-realization in work. He's the most involved into environmental problems, a feature which contrasts both with healthful and environmentalist profiles (which are very similar to each other), and even more with the disinterested one. He is also the most attracted to science at school: his level of perception of the importance of science is well above average in general, with less difficulty dealing with the study. Finally, he shows the highest level of confidence in all areas of scientific research (confidence in the benefits of science, faith in science in favour of poor countries, confidence in scientists);

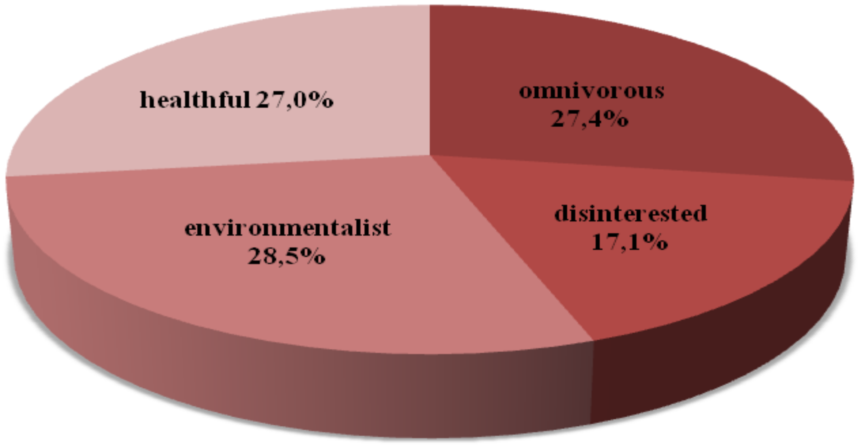
2) The disinterested: completely opposite to the first type he is characterized by higher levels of interest in the overall average in all areas. In relation to future work he is attentive to the dimensions of independence and time for himself, and also with the biggest attraction for the fame and success, but with the least sensibility towards environmental issues. He shows the whole less confidence in scientific research, especially in regard to the potential benefits of science;

3) The environmentalist: in general this is a student who expresses interest levels on average, but above the overall average in relation to all the factors concerning application of science and technology, especially in the case of environmental issues. In relation to future job he has the highest level of manual orientation. Regarding the faith in science, this profile is similar to the omnivorous, but with lower levels of trust;

4) The healthful: while bringing out a special interest in body care, for the most spectacular natural phenomena and the paranormal, students who are in this profile express some level of interest below average, particularly regarding issues related to applied aspects of scientific research. In relation to future job this profile shows importance of creativity and independence, greater propensity to have time for himself and greater rejection of handedness. As for confidence in science shows a peculiar behaviour: his faith in science is high enough, combined with a level of confidence in the ability to solve the problems of poor countries equal to the disinterested. Regarding trust in scientists and environmentalists the difference is not statistically significant.

The profile of which is the most part of students is the environmentalist, which collects 28,5% of the sample. The healthful profile is up to to 27%, while the disinterested reduces to 17% of the sample. It follows that most of the students interviewed are very or fairly interested in science and technology, albeit with considerable fluctuations.

Figure 1. Percentage distribution of 4 students' profiles



Regarding the gender distribution, among the omnivorous there is a greater presence of females, while the disinterested are distributed almost equally between males and females, although boys generally are more disinterested than the average. As omnivores even among health-conscious girls were found to be prevalent. The boys, however, contribute more of their contemporaries to the formation of the group of environmentalists.

Table 2. Students' profiles and main features

Profile	Gender distribution	Interest in science	Future work	Enviromental issue	Science at school	Trust in science
Omnivorous	Prevalence of girls	Most interested	Creativity, indipendence and realisation by themself	Greater involvement	The most attracted to scientific subjects, less difficult to study	Increased confidence in science
Disinterested	Boys and girls	Uninterested	Independence, time for themselves, fame, success	Lower sensitivity	Not attracted	The whole less confidence in scientific research, especially in its potential benefits
Enviromentalist	Prevalence of boys	Interest on average; greater interest in applications	Strong tendency in hand labour capacity	More involvement in the applications of science in the field of environmental issues	Interest on average	Similar to omnivorous profile, but with lower level of trust
Healthful	Prevalence of girls	Diversified interests, greater interest in body care and natural phenomena	Creativity, independence, greater vocation to take time for themselves, the greatest rejection for hand labour	Level of involvement below average, most of all in the application of science	Less attracted to scientific subjects, more difficult to study	Faith in science high enough, level of confidence in its benefits for poor countries similar to the disinterest

5. SIGNIFICANT FEATURES FROM A GENDER PERSPECTIVE

One of the most significant issue emerging from the types of profiles is the strong interest in the practical application of science that characterizes the prevailing profile in the sample, the "environmentalist" one. This prevalence of interest in the concrete application of science suggests some commonality of female and male students with current changes in science, which tend to undermine the classical distinction between pure science and applied science, helping to set up science as technoscience. Indeed, at present, not only technological objects pervade our daily lives - and these objects are "full of science" - but also the same scientific practice in several ways, in turn, tends to depend on the accumulation of data that technologies widely provide. Consider for instance the fact that in many areas of scientific research science depends substantially from the practices of virtual simulation.

Despite an overall proximity of students to these changes that affect science and society in our present, this high techno-scientific orientation concerns mainly boys and not girls, since boys and not girls are more present in the environmentalist profile, suggesting that the traditional male association to science is not exceeded, but only reconfigured into a new techno-scientific frame.

Less present in the "environmentalist" profile, girls are more present in the "healthful" profile, where they show a strong interest in body dimension and natural phenomena. This more female orientation towards aspects of life, that in the ROSE research is further confirmed by the prevalence of interest in life sciences (medicine first) among girls, tends to polarize with respect to the technical/technology orientation prevailing in the environmentalist majority male profile, suggesting another way of looking at science: connecting with and relating to the “self body” and nature, rather then manipulating and instrumental transforming objects of knowledge (techno science as manipulation and transformation of organic and inorganic environment).

Also the emerging interest in paranormal phenomena in this profile can be considered an additional element that tends to undermine the traditional boundaries between scientific and unscientific, in conflict with a traditional idea of scientific knowledge: a knowledge that requires a strong separation between the self (self as body) and the object of knowledge (objectivity). In other words: a scientific knowledge not influenced by subjective/emotional/body elements

In summary, from a gender perspective, the "environmentalist" profile (male-dominated) can be interpreted in alternative or in opposition to the profile "healthful" (a female predominant).

The minority of girls in the "environmentalist" profile and, conversely, their prevalence in the "healthful" profile can also be associated with their prevalence in the "omnivorous" profile. This profile indicates a female interest in non-instrumental knowledge, in a knowledge more based on the passion of knowing, and also a greater involvement of social aspects. This confirms the fact that in environmental issues, one of the topics on which research has investigated more, girls have a level of involvement more pronounced. ROSE research has also shown that humanities high school students are the most aware and involved in the environmental issue.

Another important finding from a gender perspective concerns the perception of difficulties in learning science at school among boys and girls. As it has been already noted, science at school is unattractive, it is also difficult to study, although its importance is not underestimated. In this general frame, boys seem better disposed towards science at school. Several aspects can be considered from a gender point of view: firstly, the teaching relationship as vehicles of conscious or unconscious gender stereotypes, secondly and even more, the styles of teaching science, often still attached to the concept of “innate attitude” in learning science that particularly penalize girls. This concept has a particular importance in the historical-philosophical evolution of epistemic categories internal to science, that have helped to exclude women from the history of scientific thought. The fact that they continue to be central in the educational practices of science subjects at school suggests that there are remnants of a past that tends to penalize the female gender in science education. In other words, scientific intuition, innate predisposition to learning science, [it] is still rewarding in evaluations by the school and teachers and is considered male dominated, contributing to the early formation of traditional gender stereotypes starting from the primary school and having an effect on the distance of girls from science (see, for example, Allegrini, 2009).

6. CONCLUSIONS. GENDER AND SCIENCE: BETWEEN TRADITION AND CHANGE

The diverse male and female attitude towards science documented by ROSE shows both elements of discontinuity and continuity in relation to the traditional configuration of the relation between gender and science: male “hard” sciences – female “soft” sciences. Within a large feminization process that in the last forty years involves different fields of knowledge and work, girls are more and more present in traditionally male areas of knowledge and work, such as the scientific field. This feminization represents a discontinuity's element, that happens by turns with an other continuity factor with the past: compare to the same age boys, girls are less attractive to technology-application oriented science, while appear to be much more interested in social and natural aspects of science. Indeed, in ROSE research, girls are not only more involved in social dimension of science, but also in environmental issues and in life sciences.

Not only in the case of girls, but also in the case of boys it's possible to observe an alternate of tradition and change. On one side, within the current process of science's transformation, in which science appears to be more tightly connected with technological research (techno-science), boys, and not girls, show a great interest towards apply science. On the other hand, boys are also approaching traditionally female training paths, such as human sciences, contributing to a comprehensive "scientific vocations crisis", especially in the fall enrollment in courses to undergraduate physics and mathematics area.

From a gender point of view, the persistence of a continuity trend with the past in boys and girls' training and careers paths suggests that, even if within a growing feminization process and science's transformation process, the traditional gender division among “male-hard sciences and female-soft sciences” is not overcame, but only re-configured in relation to historical and cultural change.

Still, discontinuity's aspects might be interpreted in relation to a overall crisis of the dominant role “classic-positivist” scientific ratio traditionally plays. This is why “scientific vocations crisis” especially involve those western countries which carry on the highest economical investment in science and technology. In other countries, such as Italy, whereas tradition and change still meet together, some traces of archaic culture tend to persist together with a more traditional representation of gender and science. Furthermore, in these countries, there is also the highest level of trust towards science. Indeed, compared to other European students, Italian male and female students show a highest level of trust in science, most of all in its contribution to improving the quality of life, although they also show a discontinuity in the representations of scientist, who is invested of less credibility and authority.

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STUDENT PARTICIPATION AND MOTIVE DEVELOPMENT IN SCHOOL SCIENCE: THE CASE OF HELENA'S MISTAKEN ACID

Maria Andrée

Dept. of Mathematics and Science Education, Stockholm University

Maria.andree@mnd.su.se

ABSTRACT

Previous research on science education has described various factors influencing students' participation and produced categorizations of students based on e.g. cultural background. In this article it is argued, theoretically and empirically, that an understanding of students' participation in science education needs to begin with an analysis of what activity students are engaged in. The aim is to shed light on student participation in science classroom practice and how altered conditions of classroom practice can make additional space for developing motives for learning science. Activity is conceptualized in a cultural-historical activity theoretical perspective as what transformation of objects students are engaged in. Drawing on an ethnographic study in a Swedish compulsory school, a critical incident of the participation in science education of a 7th grade girl called Helena is analyzed. The results show that altered conditions of classroom practice may produce new possibilities for student participation, and point to the impossibility of determining students as 'different kinds of students' based on *a priori* categories.

Keywords: *participation, motive development, science learning activity, CHAT*

INTRODUCTION

When I participated as an observer in 6th and 7th grade science classes in a Swedish municipal compulsory school, I overheard comments such as "I hate natural science subjects," "Hate Science!", "I'm no good at natural science subjects" or "I won't get a pass". But there are also students talking about themselves as "fat scientists" and "researchers". For some students participation in school science appeared to lack personal meaning, whereas for others participation in school science appeared meaningful beyond the actual classroom task and significant in relation to a comprehensive development of identity.

Previous research on science education has described various factors influencing students' participation and learning outcomes in science education such as ethnicity, language, culture and socioeconomic status (Lee & Luykx, 2007). In Sweden, analyses made by the Swedish National Agency for Education (2009) show statistical relationship between parents 'educational level and students' school performance on achievement scores. Students' participation in science education has also been conceptualized in terms of border-crossings between different cultures (Cobern & Aikenhead, 1998). Costa (1995) described a model for understanding how students' responses to science are related to the degree of congruency between their worlds of family, friends, school, and science. Costa identified groups of students with different cultural backgrounds and labelled them Potential Scientists, Other Smart Kids, "I do not know" students, Inside Outsiders and Outsiders. Cobern and Aikenhead (1998) then described students' border-crossings between cultures of family, peers, school and science as smooth, manageable, hazardous or virtually impossible. The categorizations are based on an understanding of a student as an individual representative of particular cultures that are in conflict or consistent with school and science culture. With these categories particular identities are ascribed to individual students, in relation to Science, with reference to practices outside the science classroom (also Science is understood as singular and simplistically represented by school science cf. van Eijck, 2007). Consequently, the categories imply an individualistic static perspective on the student. Critique against this kind of research, from a Cultural-Historical Activity Theoretical (CHAT) perspective, emphasize that identity is a complex matter and that an analysis of student identity in relation to one specific practice results in a very abstract, unrealistic story (Williams, Davies & Black, 2007).

In this paper, I argue that students' participation in science classroom practice cannot be properly understood with reference to cultures outside of school practice. Instead, we need to take our starting point in the activities students' are participating in. The aim is to shed light on student participation in science classroom practice and how altered conditions of science classroom practice can make additional space for science learning and developing motives for science learning.

LEARNING, PARTICIPATION AND MOTIVE DEVELOPMENT

In CHAT human activity is understood as a system of relations in which societal needs are central. A constituting characteristic of activity is objectivity i.e. the object which is purposefully transformed (Leont'ev, 1977/1986; cf. Roth et.al., 2005). Education is a specific form of human activity, embodied in school practice, where teachers and students collectively undertake actions of making school 'school'. The question of what activity students engage in within school practice is an empirical question concerning what transformation of objects students are engaged in.

CHAT builds upon a dialectic relation between agency and structure, which means that agency and structure mutually presuppose and constitute one another (Roth, 2007). Most researchers who draw on CHAT focus on its structural aspects as developed by Engeström (e.g. 1999; 2001) in his triangular model of human activity systems. But a structural perspective on activity systems does not allow us to theorize individual learning or personality formation adequately (op cit). In this paper, I focus on students' development of motives for participation in activity, mainly drawing on the works of Leont'ev (1977/1986), Lomov (1981) and Hedegaard (1999).

Incorporation into any new community or collective give rise to new motives for activity and transforms the already formed motives of the individual (Lomov, 1981). Motives are developed through collective cultural practice and simultaneously related to a person's goals and characterize the person's activities. At a general level, educational content can be understood in terms of what educational motives are being realized in classroom practice (cf. Chaiklin, 2001). The objective of science education can be described as transformation of children, i.e. developing students' motives for participation in science-related activities (Chaiklin, 1999, 2001; Hedegaard, 1988). For teachers to develop learning motives for some subject matter learning they need to bring the student into situations where the activities acquire personal meaning, so that the student acquires a motive to enter into these kinds of activities (Hedegaard, 1999).

Previous research show that different students, superficially part of a common practice, may be engaged in activities corresponding to different motives (cf. Andrée, 2007; Hasse, 2002). In Swedish lower secondary school science practice, students are shown to participate in two different kinds of actions: *production and reproduction of correct answers*, corresponding to a motive of formal qualification, and *development of conceptual relations*, corresponding to a motive of science learning and enculturation into science communities (Andrée, 2007). In education aspects of personality is produced through the social relations constituted between students, students and teachers and between students and cultural resources of educational practice. A result of students' participation in different activities is that students are formed differently in relation to science. Consequently, science classrooms are not only places for learning science subject matter but also places where identities are developed through students' engagement in activity (cf. Kelly & Sezen, 2010).

FIELDWORK

This study was part of a larger ethnographic study. In pursuing an ethnographic line of research I attempt to account for particular cultural historical processes as practiced by particular people in a particular setting (cf. Wolcott, 1999 p. 253).

I have conducted ethnographic fieldwork in two science classes, grade six and seven, in a Swedish midsized compulsory public school during one school year. The school is situated in a socioeconomically and ethnically mixed city district. The two science classes are taught by Ann. Ann is in her mid thirties, holds a Bachelor of Science and Mathematics education, and has taught science for 3 years. A variety of data, from a broad range of classroom activities, was collected through participant observation; including field notes, audiotape recordings, formal and informal interviews, teaching materials, and some student work. Based on a preliminary analysis of field notes and transcribed interviews some of the audiotape recordings were chosen for verbatim transcription and detailed analysis.

In this paper, I analyze the work of Helena during a practical lesson in seventh grade science class. Helena works together with two other girls: Lisa and Jessica. The girls are usually engaged in production and reproduction of correct answers as part of an educational activity and their work can be characterized in terms of social positioning at odds with school science. The particular lesson is chosen as it involves a critical incident of an unexpected occurrence leading to a change of Helena's participation in classroom work. During the lesson the three girls use a 'wrong' acid and receive a green solution instead of a blue.

The tasks of the day are labelled: (I) "metallic oxide in acid" and (II) "metal in acid". In the first task students are instructed by the teacher to (1) dissolve cupper oxide in hydrochloric acid, (2) describe the process using chemical formulas and (3) formulate what salt they have produced. The teacher tells the students to write both the general and the specific formula of the salt produced in their conclusions in the laboratory report. The second task, which is only briefly mentioned in this article, is called "Metal in acid". Here, students are to dissolve zinc in sulfuric acid. The procedure is at large the same as in the first task. The intended educational content of the lesson can be summarized with the reaction formula which students are intended to write as conclusions in their laboratory reports (see table 1).

Table 1: Reaction formula to be written in laboratory reports

General: metallic oxide + acid → salt + water
Specific: cupper oxide + sulfuric acid → cupper sulfate + water
General: metal + acid → hydrogen + salt
Specific: zinc + hydrochloric acid → hydrogen + zinc chloride

THE CASE OF THE MISTAKEN ACID

Excerpt 1
I won't get a pass in Science […] I won't take N V or N A [short for science programs in upper secondary school]

The quote above is from Helena a couple of months prior to the lesson analyzed in this article. On another occasion, Helena talks to the tape recorder on the bench in front of her, used for my collection of data, about how boring Science is and much she hates Science.

Helena repeatedly marks her rejection of school science and positions herself at distance from work in the science classroom. In the laboratory task "Metal-oxide in acid", however, Helena engages in a discussion with the teacher and after having finished the laboratory task of the day she walks around the classroom, helping other groups of students to formulate conclusions. The critical incident was that the three girls used the 'wrong' acid and received a green solution instead of a blue. In the following, I give an account of the work of the three girls during the practical lesson on salt production.

Setting up the laboratory task

When the teacher finished her introduction to the laboratory task, Helena and her co-experimenters Jessica and Lisa retrieve the needed equipment. They assemble the Bunsen burner with tripod, lattice and cups. Helena goes to the front desk to fetch acid in a beaker. She brings the cup back to the bench and then all three girls go to look for the one jar of copper oxide which some other group had brought back to their work bench. The girls use a spoon to pour copper oxide into the acid. They are then supposed to heat the mixture in order to dissolve the copper oxide but Helena and Jessica begin to argue about who is to dare to ignite the Bunsen burner.

The procedure of igniting the Bunsen burner causes conflict and agony in the group: Who is to ignite the Bunsen burner? Who dares to? Helena and Jessica start fighting over who is to do it and the teacher step in as a mediator.

Excerpt 2

Lisa: hey, you can ignite it
Helena: no, I don't want to do that stupid crap
Jessica: no but hey don't do it
Lisa: now
Jessica: it's not to be turned on now
Lisa: yes
Jessica: no
Lisa: yes, now it is
Jessica: no but I don't want to, I don't want to
Helena: no but com'on (.) oh you're *chicken* [said in English]
Läraren: what's the problem girls?
Jessica: I don't dare to do that, I just dare to adjust that and then she calls me chicken(.) she doesn't even dare to do any of it
Läraren: try now Jessica
Jessica: I don't dare to (.) I don't wanna burn my hand
(matches are lightened)
Jessica: look there (.) I would have been scared to death
Helena: *super maan* [in English]

Helena calls Jessica chicken but also says that she doesn't want to "do that stupid crap". The Bunsen burner is circumscribed by fears for making dangerous mistakes, of being burnt and scared. After they've succeeded to ignite the Bunsen burner, Helena exclaims: "hate science!".

Getting a green solution

Lisa reads aloud from the instruction that they are to use diluted hydrochloric acid. Helena asks the teacher if "this acid here is diluted" and receives the answer that all acid is diluted. The girls then pour acid in a beaker. When the copper oxide begins to dissolve Jessica notices that the solution is turning green:

Excerpt 3

Jessica: Lisa, oh Lisa, it is green.
Helena: (inaudible) cause we did wrong
Lisa: why?

Jessica: it's supposed to turn blue
Helena: yes we used the wrong acid (inaudible)
Jessica: oh shit

Helena, Jessica and Lisa solved the copper oxide in hydrochloric acid, instead of in sulfuric acid. They note their 'mistake' when they get a green solution, unlike the other groups who receive a blue solution.

After having solved zinc in hydrochloric acid (i.e. task II) they set out to write results and conclusions in their laboratory reports. The girls call for the teacher for help. After a short discussion on their observations of how the color changed from black (the copper oxide powder) to green, Helena asks the teacher what the beaker contains:

Excerpt 4
Helena: what's that?
Teacher: ehm metallic oxide plus acid is salt plus (.) something (.) then you have one there that is metal plus acid is salt plus something
Helena: we did the acid first, so we're supposed to write that first or
Teacher: that doesn't matter
Helena: metallic oxide plus acid (.) what's that? [salt
Teacher: [yes that is what we wrote
Helena: salt
Teacher: yes salt plus what? that was what you had for homework til Friday
(Helena turns pages in her book)
Teacher: that there Helena, turn that (.) the blue one high up
[…]
Jessica: what's that called in there, the liquid (.) what is it after methods?
Teacher: then that was an acid (.) what acid did you use? you had hydrochloric acid
Helena: mm
Teacher: then that was hydrochloric acid and cupper oxide
Helena: yes, but it says water plus cupper sulfur
Teacher: but look at it (.) metallic oxide plus acid is some form of salt and water
Jessica: what salt will it be?
Teacher: well that depends on what you use for-
Helena: metallic oxide and hydrochloric acid
Teacher: yes then you get the metal and acid forming a salt that is called (.) it can't be called cupper sulphur because you don't have any suphur ions
Helena: no then you'll get
Teacher: then you'll get cupper and what's the ion of hydrochloric acid?
Helena: ehum that is an acid so it'll have to have hydroxide ions
Teacher: no then that is [a base but what about the other ion
Helena: [ehum ehum hydrogen ions
Teacher: hydrochloric acid contains hydrogen ions plus another ion
Helena: that I don't know
Teacher: yes, what does the formula look like
Helena: chlorine
Teacher: yes, and what is it called if you make an ion out of chlorine?
Helena: chloride
Teacher: then you'll get cupper chloride

Helena asked the teacher about what happened and the teacher suggests that they took the wrong acid (which Helena already concluded in excerpt 5). Helena continues to talk to the teacher about what salt they produced and she contributes with facts about which chemicals they have used and the composition of ions in hydrochloric acid. The fact that Helena and her co-experimenters got a green solution, instead of a blue, focuses her attention on the acid that they used hydrochloric acid instead of sulfuric acid and that the choice of acid was important. The teacher guides Helena through reasoning about what chemical reaction has occurred.

The green color also attracts attention from other students. Chandra, from a different group asks: “How did yours turn green? Helena how could your stuff here get green?” “Because we happened to put in the wrong acid”, Helena explains. Another student exclaims: “God, theirs is green”.

Hannah, who is said to be the most successful girl in science class by both other girls and the teacher, comes to discuss her conclusion with the teacher. Usually the other girls in class would try to copy Hannah’s conclusions but now Helena steps in to help Hannah:

> **Excerpt 5**
> Hannah: so, what should we write for conclusion?
> Teacher: the general formula plus the formula for the salt you made
> Helena: on which one are you? are you on this one?
> Hannah: no, I'm on this here blue one
> Helena: but look here, it says, metal plus acid and then you’re to write zinc plus hydrochloric acid

In excerpt 5 Helena displays confidence as a knowledgeable student in her interaction with Hannah. When Helena has finished writing the lab report, she walks around the classroom, explaining to other students why her group got a green solution instead of a blue, and also helping other groups to formulate conclusions in their laboratory reports. Helena does this, even though lab work practice allows students to leave for recess when they have finished their laboratory tasks and handed in their reports.

DISCUSSION

The case of the mistaken acid is an example of how altered conditions of classroom practice produce new possibilities for students’ participation in school science. Helena is usually engaged in an activity of science education i.e. she deals with the tasks given in order to produce what is needed for completion of the course which primarily corresponds to a motive of formal qualification (i.e. attaining a grade in school science and receiving a complete compulsory school diploma). She has also repeatedly positioned herself at odds with school science, e.g. in the beginning of the analyzed lesson in question when arguing with Lisa about the Bunsen burner.

The transformation of the laboratory task created conditions for a desire on Helena’s part to develop knowledge about the produced salt, in other words, conditions for development of motives for engaging in science learning activity were created. When Helena discovered that the solution became green instead of blue the lab work took an unexpected turn. The result is visible, surprising and requires an answer. Here, Helena, Jessica and Lisa produce a different salt than other students and the conclusions of other students cannot be used as ‘right answers’. What Helena, Jessica and Lisa have produced is no longer the planned pedagogical illustration of the general chemical process of salt production by dissolving metal oxides in acid. On one level, their work is in line with the intended educational content of the original task; as the choice of acid was subordinate to the illustration of the chemical process. From a teacher’s perspective, the task could just as well have involved hydrochloric acid as sulfuric acid. In school laboratory practice, however, the embodied task that the students work with is to solve the copper oxide in sulfuric acid. The laboratory task at hand was transformed from a routine task to a ‘real problem’. Helena and her group also produced something unique and different. We can compare the importance of clothing as an identity marker. In a school with school uniform dress code, clothing will not function as identity marker in the same way as in a school without uniforms. Similarly, school work with educational content is not something specific to particular students in everyday school practice when everyone is working with the same content.

Previous research on teaching science has described a number of factors relevant to our understanding of students' achievement and participation in the science classroom (cf. Cobern & Aikenhead, 1998; Costa, 1995; Lee & Luykx, 2007). What makes Helena's work exciting is that it demonstrates the impossibility of determining students as different kinds of students based on *a priori* characteristics. Based on information before the mistaken acid one might, using Costa's (1995) categorizations, have categorized Helena as an *"I-don't-know" student*, or possibly as *Other smart kids* – she positions herself at marked distance from, and in conflict with, school science and Science while engaging in work to produce and reproduce correct answers in order to receive a passing grade. What has changed in the case of the mistaken acid is not Helena's domestic conditions, but conditions for schoolwork. Characteristics such as socio-economic background, ethnic background or gender can always only partially account for development of motives for activity and identity. Categorization of different types of students may be a functional tool for categorizing students' work in the classroom, but it is not reasonable to make this type of categorization of individual students.

Students' participation cannot be determined in advance, but participation is always embedded in a particular practice. Biesta and Burbules (2003, p 111) write: "...the world in which we live is ever-changing and ever-evolving". This means that every situation we encounter is in some respect unique, albeit many of our actions are habitual and that the activity systems in which we engage both constrain and open up certain possibilities for action.

CONCLUDING REMARK

The mistaken acid becomes an example of how new conditions for participation in practice enable the activity of development of conceptual relations to acquire personal meaning a student. For Helena the mistake enabled her to engage in an activity of science learning. The educational challenge for science educators is to develop science classroom practices where all students will be provided opportunities to engage in science learning.

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BIOETHICAL EDUCATION ON DELIBERATION: THE VIEWS OF A NOVEL

Joana Araújo

Bioethics Institute of Portuguese Catholic University

jaraujo@porto.ucp.pt

Susana Magalhães

Fernando Pessoa University; Bioethics Institute of Portuguese Catholic University

susanavtm@gmail.com

Ana Sofia Carvalho

Bioethics Institute of Portuguese Catholic University

acarvalho@porto.ucp.pt

ABSTRACT

Ethics is the study of the moral basis of human behavior that aims to determine the best course of action. Bioethics, as a transdisciplinary area, based both on ethics and on life sciences, reflects upon the ethical problems raised by new technologies and scientific research. One of the main tools to tackle bioethical problems is deliberation, a procedure that attempts to analyse problems, weighing up the principles and values involved as well as the context of each case. Due to the complexity of deliberation, educational projects should be promoted, providing the practice necessary for correct deliberation and raising awareness of the current ethical issues.

It is our purpose to present a framework for ethical deliberation throughout the use of literature. Literary texts are essential, since they show human beings acting in space and time and they give the readers an opportunity to deliberate on ethical issues. Based on a literary text, we will reflect upon a controversial ethical issue - Preimplantion Genetic Diagnosis (PGD).

Keywords: *Bioethics, ethical deliberation, Literature, Preimplantation Genetic Diagnosis*

1. A MODEL FOR DELIBERATION

Ethics reflects upon human conduct *aiming at the good life with and for others, in just institutions* (Ricouer, P.,1992,p. 172). The issue we have to address is how we can decide the best way to act, choose the most prudent course of action, when we face conflicting principles/values as alternatives that exist precisely because we are free human beings. The imperative to decide and act is therefore inscribed in a context of free will, which is nonetheless determined by individual and social influences: 1) individual influences, such as age, character, natural talents, circumstances; 2) social influences, such as education and society. According to Aristotle, who taught deliberation as the main procedure of ethics, (moral) wisdom and (moral) knowledge originate from reflections on and within concrete situations, being thus impossible to separate moral truth from experience. Moral decisions, Aristotle further emphasized, are not a product of instrumental reasoning, calculation or logic, but flow from wise judgment, perceptiveness, imaginative understanding and an engagement with practice. In a nutshell, the meaning and construction of morality is inherently contextual and temporal.

Consequently, the first step to promote solid deliberation is to make individuals aware of the different factors that intervene in this process, of the different steps to be followed, and most importantly, of the situational nature of deliberative procedures. Moreover, one should also provide them with the opportunity to develop second-degree virtues, i.e. virtues that allow one to consider moral problems carefully and to act according to the results from the ethical reflection previously done. It is not enough to be compassionate, brave or benevolent (first-degree virtues), because when it comes to act, the second-degree virtues are the ones that make the bridge between the moral judgment and the intention to choose a course of action that respects this judgment. We think that this bridge can only be built by educating the future citizens who will have to decide upon controversial issues affecting their own lives and the lives of the next generations.

Different models have been designed to describe the ethical decision making process, being one of them by T.M. Jones (1991) – *An issue contingent model,* which is based on the idea that the moral intensity of a particular situation influences the way the individuals perceive that situation and the way they decide to act. There is thus a correlation between the moral intensity of a situation and the perception and ethical intention of the subject. In Jones' model moral intensity is defined according to six components: **magnitude of consequences**; **probability of effect**; **temporal immediacy; concentration of effect**; **proximity**; **social consensus**. A person's collective assessment of these characteristics results in a given situation's moral intensity. In general, issues with high moral intensity will be recognized as ethical dilemmas more often than those with low moral intensity, leading to a positive relationship between **moral intensity** and **perception** of an ethical problem. Furthermore, issues with high moral intensity have a positive relationship with an individual's **intention** to behave in an ethical manner. The fact that moral intensity is a key component in ethical decision making underlines the need previously mentioned of educating individuals on potential consequences and implications of ethical problems, so that their perception and decision making skills can be sharpened, when they encounter ethically sensitive situations. Other authors have proposed different models of ethical decision making, which share some items with Jones' model:

- Dawson W. Carlson et.al. (1997) have analyzed the impact of concentration of effect, probability of effect and proximity on the ethical decision making process and they added a variable that is not considered by Jones in his model – **Orientation.** This variable refers to the role played by the decision maker as the subject of the action, as an external advisor or as an element of an organization.
- Susan J. Harrington (1997) has also tested two of Jones's model steps (moral judgment and moral intent), by analyzing the strength of **social consensus** and of the **seriousness of consequences** on these steps. Moreover, the study goes further and examines different levels of social consensus and how they interact with important individual characteristics of **rule orientation** and **denial of responsibility** (how the former influences moral judgment and how the latter influences moral intent). Based on Jones' model, Harrington states that social consensus, i.e. the degree of social agreement that a proposed act is evil or good, influences ethical behavior: the stronger the social consensus against some unethical behavior is, the more likely it will act as instructions for behaviour. However, Harrington says that moral orientation and moral judgment do not give full explanation to moral behaviour, since this one is also related to moral intent – what the individual intends to do in an ethically controversial situation. Possible reasons for the gap between moral judgment and moral intent are: considering other personal values more important than the moral ones at stake; lack of recognition of an ethical issue or previous exposure to the issue, thus responding with less deliberate thinking; or neutralizing moral judgments by **denying responsibility (RD)** for the results. **RD** mediates between self standards

(moral orientation and moral judgment) and ethical behaviour: i.e. RD acts to neutralize self standards. Therefore we can say that whenever there is lack of social consensus against a particular type of behaviour, it will be more likely that those high in RD will agree with an unethical behaviour.

Jones' model (1991) as well as other models of ethical decision making (Gracia, D., 2003; Rest, J.R., 1984; Trevino, L. K., 1986; Vitel et. al., 1993) - see references to other models - usually include four basic stages: 1) **recognition** of the **moral issue**; 2) **moral judgment** about which course of action is morally right; 3) formation of a **moral intent**, that may not accomplish the moral judgment made before if this one collides with the individual's previous desires; 4) **moral behaviour**, which requires the motivation to act according to the moral intent.

2. BIOETHICS AND LITERATURE

Nowadays ethical decision making plays a key role in response to the dizzying advances in technology and the profound socio-political changes in a world caught up in globalization and multiculturalism. Therefore, it would appear to be of paramount importance that this new area of knowledge be properly disclosed and explained to civil society in order to seek their engagement. In fact, it is more and more important that students and society in general understand the need of well-reasoned judgments, combined with respect and empathy for other approaches.

It should go without saying that the transdisciplinary nature of bioethics demands different perspectives when dealing with ethical issues. These varied points of view are usually grouped under two kinds of approaches, mainly the *wide-range approach* and the *in-depth* one. The former is mainly related with the global and extensive view of ethical issues by responsible politicians, mass media, inter-disciplinary research groups and opinion makers; the latter is the basis of the research carried out by philosophers, religions and ethicists. Both approaches require educating the way we see the world, the way we speak about it, the way we reflect upon it and the way we act (hopefully) according to the steps taken before. Choosing the most prudent and the most appropriate course of action in a particular setting, with and for the others, considering not only the individuals directly affected by the decision, but also their community and the biosphere, was also the project outlined by Van Rensselaer Potter in his papers "Bioethics: the Science of Survival" (1970) and "Bioethics: Bridge to the future" (1971). Potter had a global perspective of Bioethics as a discipline that could set up the bridge between the ethical values of Humanities and the biological facts of Life Sciences, which he considered to be indispensable to guarantee the survival of Human Kind. Therefore, global bioethics is a concept coined by Potter, which he later included in the title of one of his works: "Global Bioethics: Building on the Leopold Legacy" (1988). Only by educating our sight can we fully understand the concept of global bioethics, focusing our reflection not only on the individuals, but also and most importantly on the Other that is part of each individuals' sense of their own identity. Moreover, education can provide citizens with the tools to participate in ethical deliberation on issues that concern not only the nature of scientific research and doctor/patient relationship, but also the survival of Human Kind with a human sense. Actually, these days Bioethics is considered by many experts as a civic ethics, i.e. as an ethics shared by the members of a community who see themselves as co-authors of the narrative of that society. According to M. C. Patrão Neves and W. Osswald (2000), the three main reasons for the current role of Bioethics as a civic ethics are: the lack of universal moral foundations, which can either lead to deep relativism or to the search for rules and guidelines applied to the particular setting under analysis; the Death of God, of the Author, of the unified subject, which has also led to the need of wide deliberation procedures, from different perspectives, that can be achieved by Bioethics due to its transdisciplinary nature; furthermore, the fact that Bioethics has been organized in institutions has also contributed to its functional role in our days. As applied ethics, Bioethics has a public dimension that has a strong impact on public opinion, providing the citizens with information and formation about the ethical issues underlying different areas of human action. The wide range of resources available in bioethics education provides different tools that can be explored according to the topic under discussion, the subjects participating in the ethical deliberation procedure and the kind of approach used to analyse the ethical issues. Choosing literary texts as a resource for Bioethics education means that this approach must be anthropological, bio-cultural, a revision of ethics as a dialogical search and not as a source of ready-made answers or recipes:

Today there are logocentric habits and an educational philophy focused on conveying information and training experts, which highlights the pragmatic and the scientific, the efficient and the instrumental dimensions of human life, but forgets the key role of imagination and memory. In fact,memory and imagination were the basis of a free, critical and creative thought of the greek civilization (Clavel, 2004, p. 77, our translation)

The metaphorical structure of literary texts – which implies a reading strategy of suspending the literal reference and locating the meaning between the world of the text and the text of the world – gives them the power to release a second-degree reference that provides the reader with the opportunity to see something in a certain way, thus shedding new light on the world and increasing human knowledge. Umberto Eco (2002) conceives of Literature as an enlightening source, which contributes to the building of language and cultural identity, while disclosing the vulnerable trait of humanity: literary texts reveal the impossibility of changing the course of their story, even if it is against the readers' will. Literature shows human beings acting in space and throughout time, making the readers aware of the limits and of the conditioning of their existence together with their freedom of choice. David Lodge (2009) adds to the ideas outlined by Eco that literary texts also express the uniqueness of each human being, since they are written in a singular and unrepeatable way, even when they recycle stories or import characters from other stories. It is this singularity together with a universal dimension that makes literary texts the place where experience can be deeply represented, making the reader see what characters tell, even when they tell it in the first person:

There is no ethically neutral narrative. Literature is a vast laboratory in which we experiment with estimations, evaluations, and judgments of approval and condemnation through which narrativity serves as a propaedeutic to ethics. (Ricoeur, P., 1992, p. 115)

It is important to notice, that the knowledge provided by literary texts will only be achieved through hermeneutics, i.e. through interpretation, which gives the reader an important role in this linguistic process rooted in the objective facts of the world and in the subjective interpretation of the individual who interprets them. It is precisely this hermeneutic process that sets up a bridge between narrative and identity:

By narrating a life of which I am not the author as to existence, I make myself its coauthor as to its meaning (…) It is precisely because of the elusive character of real life that we need the help of fiction *to organize life retrospectively, after the fact, prepared to take as provisional and open to revision any figure of emplotment borrowed from fiction or from history*. (Ibidem, p. 162)

2.1 The views of a novel

My Sister's Keeper, a novel by Jody Picoult (2004), makes us see this process of building identity through narratives told by the different characters that *attest* the Self that states *here is where I stand*, the Self that remains as time goes by, the Self that keeps the promise of being *Oneself as Another*. All the narratives embedded in Picoult's novel are thus linked by the hermeneutical process that created them, that is represented by them and that they in turn ask from the readers.

As Ricoeur points out in *The Rule of Metaphor* (2006, p. 6), the work of interpretation involved in understanding a metaphor is itself part of the knowledge provided by metaphorical language, which, in the case of Jodi Picoult's novel, could be translated as follows: the different perspectives from the characters given to the reader are part of the reader's interpretation and they underline the role of the very process of building a way of seeing the world.

I was born because a scientist managed to hook up my mother's eggs and my father's sperm to create a specific combination of precious genetic material. (pp. 7-8)

The Fitzgeralds (Sara and Brian) have a two-year old daughter, Kate, who has acute promyelocytic leukemia and are informed by the oncologist -- Dr. Chance -- that, since Kate's brother, Jess, is not a genetic match, they have to find an unrelated donor in the national marrow registry or have another child, a savior sibling (Anna). Interestingly, the slippery slope argument related to the use of IVF (medically-assisted reproduction) is part of a conversation between the reporter for the newsmagazine, Nadya, who interviews the Fitzgeralds, and this couple:

Nadya looks down at her notes. 'You've received hate mail, haven't you?'

Brian nods. 'People seem to think that we're trying to make a designer baby.'

'Aren't you?'

'We didn't ask for a baby with blue eyes, or one that would grow to be six feet tall, or one that would have an IQ of two hundred. Sure, we asked for specific purposes – but they're not anything one would ever consider to be model human traits. They're just Kate's traits. We don't want a superbaby; we just want to save our daughter's life. (pp. 102-3)

According to the slippery slope argument, by allowing savior siblings, which may be morally acceptable, we will start a slide towards other practices that are ethically unacceptable, such as creating designer babies. In bioethical discussions of PGD and Prenatal Diagnosis, eugenics and slippery slope are key concepts that refer to the potential danger of opening the lid of the Pandora's box, leading to a perception of humanity based only on Utilitarianism. This utilitarian attitude could range from treating the other as an Object to assuming the right to create tailor-made human beings (eugenics, the science of improving the human stock according to Francis Galton's definition in 1883). On top of this, PGD is ethically controversial because of the surplus embryos, that may be destroyed in spite of being healthy:

The doctor was able to screen several embryos to see which one, if any, would be the ideal donor for Kate. We were lucky enough to have one out of four – and it was implanted through IVF. (p. 102)

In *My Sister's Keeper*, the IVF is used as a technical procedure to find out an HLA matched donor, combined with PGD to select the embryo that would save Kate and it is precisely this saviour trait that seems to efface the identity of Anna, who is born with the purpose of giving life to her sister:

Although I am nine months pregnant, although I have had plenty of time to dream, I have not really considered the specifics of this child. I have thought of this daughter only in terms of what she will be able to do for the daughter I already have. (p. 100)

Considering Kant's principle of humanity, *which states that one should act in such a way that you always treat humanity, whether in your own person or in the person of another, never simply as a means, but always at the same time as an end*, Sara's statement quoted above can be read as the disclosure of the potential utilitarianism underlying some procedures of IVF. There are a number of fallacies misguiding the reflection upon the use of IVF, and one of them is the conviction that couples have the right to have a child, as if the child could be considered a commodity, something that one can possess, the object of another's power. Autonomy is often used to justify the translation of the *wish* to have a child into the *right* to have one, which is also fallacious, because autonomy can only be ethically acceptable when it is applied to oneself or to the respect for the other, never as a claim for the other, in this case, a claim for the child to be born. (Patrão Neves, M.C., 2008)

When the Fitzgeralds decide to have another child to save Kate, they act out of the assumption that they have the right to choose between having another child or letting Kate wait for a donor and probably die. From a Kantian perspective, autonomy is the intrinsic characteristic of the Will that makes it rule for itself according to a maximum that should become a universal law. Therefore, freedom and morality are dependent upon each other, and the community built on these principles is open to the respect for the person seen as an end in him/herself and not only as a means. The recognition of one's dignity by the others is undermined by a narrative that reduces Kate to her disease and her siblings to *stereotyped* figures in a plot:

'Don't mess with the system, Anna,' he (Jess) says bitterly. 'We've all got our scripts down pat. Kate plays **the Martyr**. I'm **the Lost Cause**. And you, you're **the Peacekeeper**.' (our highlights, p. 15)

The isolated individualism, where duty is replaced by the right to have and to be according to the individual's wish, is the result of seeing autonomy as the quality of being free from all external coercion (negative meaning), which contrasts with the respect for autonomy defined by Beauchamp and Childress:

To respect an autonomous agent is, at a minimum, to acknowledge that person's right to hold views, to make choices, and to take actions, based on personal values and beliefs. Such respect involves action, not merely a respectful attitude. It also requires more than non-interference in other's personal affairs. It includes, at least in some contexts, obligations to build up or maintain other's capacities for autonomous choice, while helping to allay fears and other conditions that destroy or disrupt their autonomous actions. (Beauchamp, T.L.; Childress, J.F., 2001, p. 63)

To enact this respect for autonomy, one should not take this principle as an isolated one, ruling over the other bioethical principles, as if it were autonomous from beneficence, nonmaleficence, integrity, solidarity and vulnerability. In fact, individuals are *emotional, embodied, desiring, creative, and feeling, as well as rational, creatures (Mackenzie, C.; Stoljar, N., 2009, p. 21)*, and only by acknowledging these features, do we respect each individual's autonomy, the capacity to choose their course of action, as well as their own communities, the so called *communities of choice*:

[T]o value these communities is to reject the strong descriptive claim that we are so constituted by social relations and shared values that we are unable to reconsider our attachment to them. (ibidem, p. 68)

Interestingly, relational autonomy and the agent's freedom of choice imply human features that are also worked out by reading literary texts, namely *memory, imagination and emotional disposition and attitudes* (ibidem, p.21).

Reading *My Sister's Keeper* in search for Anna's identity - *the sister's keeper* referred to in the title - we are faced with a narrative about *invisibility* and *ready-made scripts*, with characters looking forward to having their autonomy/identity respected/recognized:

My throat closes like a shutter of a camera, so that any air or excuses must move through a tunnel as thin as a pin. I'm invisible (…) (p. 54)

My father looked right at me, but he didn't answer. And his eyes were dazed and staring through me, like I was made out of smoke. / That was the first time I thought that maybe I was. (p. 245)

Parents control everything, unless you are like Jess and you do enough to upset them that they'd rather ignore you than pretend you actually exist. (p. 302)

By acting according to one's values, we actually give value to the Value and this could stand as the main argument for being against the use of PGD to save an existing child: the act of having a child for utilitarian reasons withdraws the value of the dignity that we apparently address to the life we are trying to save. The deliberation process that leads to the decision of *giving birth to a saviour* does not focus on the context where the decision will be acted out, but only on two elements of the context –the sick child and the parents. Therefore, we could say, that the ethical issues of *My Sister's Keeper* are raised by a deliberation model supported by a linguistic structure, which is based on a substitution theory or the theory of making one term invisible while putting the other on the stage. This linguistic structure or trope, which fosters the invisibility of some characters and the excessive visibility of others, is metaphor considered as the trope that allows us to see a familiar thing in a new light. For Aristotle, metaphor – e.g. *Achilles is a lion* - borrows from one domain (that of animals) and is a substitution for a word belonging to another domain (that of people), creating an alien effect and providing the reader with new information. The substitution theory underlining this concept of metaphor on the level of the word is related to the reasoning strategy used to decide whether to have a savior sibling for Kate. In fact, if one deliberates by considering the individual meaning of a certain human action (PGD as an instrument used to have a matched donor, a medicine embryo, a saviour) and its consequences, without taking into account the values underlying it and the narratives of the different individuals involved, then we could say that the deliberation process would be ruled by a metaphorical/substitution theory. This is the main reason why Anna tells her story against a narrative that tries to efface her; the reason why this novel is made up of different narratives, each one trying to build up their own identity - the narrative identity that bridges the gap between the *Ipse (who I am)* and the *Idem (what I am)* (Ricoeur,1992); the reason why Anna sees herself being looked at as a word replacing another word – Kate. Paradoxically, Kate's voice is never heard except for the echo of her words in other people's mouth and after Anna's death. It is ironical that the one whose life is being kept at the expense of respecting the others' autonomy is not given her own voice until her sister's death.

On the other hand, we could consider metaphor as a trope based on tension and not substitution, on interaction and not on replacement. For Ricoeur metaphor works not on the level of individual words, but at the level of the sentence and of the discourse, thus it does not work by substituting a *deviant* term for another *proper* term, but by the interaction between the focus (Anna) and the frame (Kate) within the context of the whole sentence (the family). *Anna is Kate* is the metaphor that should not have been accepted by the family at the moment they considered having a child that was not part of their parental project and that was born for purposes other than giving life to her. The other metaphorical proposition – *Sara and Brian are Kate* – should also have been eliminated if the deliberation process had been carried out by considering all the elements that are actually affected by it: Sara, Brian Kate, Jess and Anna. The first step in this deliberation procedure should be to analyse *the context*, the *conflicting values/principles at stake*, to reflect upon the *situational factors* that influence the ethical decision making: life stage, cultural background, general knowledge and specific information about the issues being discussed, peer pressure, social consensus, seriousness of consequences and individual characteristics, such as rule orientation and denial of responsibility. By applying this framework of analysis to each character's course of reflection and decision making, we are allowed to actually practise the ethical deliberation process, becoming aware of the key role played by **Orientation**, i.e. the role played by the decision maker as the subject of the action (the characters of the novel), as an external advisor (the readers, when they step out of the novel and perceive it from the border line between reality and fiction) or as an element of an organization (the characters of this novel who play the role of doctors in hospitals, geneticists in labs, judges in courts). Moreover, by getting inside the story as readers who see from the characters eyes, we are also faced with the impact of moral intensity on ethical decision making, mainly the impact of **temporal immediacy, probability of effect and proximity**. On the other hand, moving out from the plot of the novel to our own *story*, we can now have a wider and at the same time deeper view of the ethical issues at stake, which provides us with the possibility of producing an answer and yielding a choice or decision, but not of finding **the** right answer, since, as we stated before, this is not the aim of ethical deliberation.

Let us focus now on Anna's decision to stop being a donor to Kate and on Kate's decision to stop being submitted to medical procedures aimed at finding the cure at all costs. Anna builds her own narrative based on key concepts developed throughout the story, mainly the concept of otherness, utilitarianism and invisibility. It is a narrative written both by Anna's experience and by her parents' version of their family's life. Anna decides to stop to stand up for her autonomy and integrity. On the other hand, there is Kate, whose narrative is mostly conveyed by other characters' voices, thus making us read it as a narrative about an identity that has been reduced to one single trait: cancer. Her decision to stop is thus motivated by the same principles that justify Anna's decision: autonomy and integrity. If we go back to the moment when Sara and Brian are faced with the choice of using PGD to have a matched donor for Kate, they also claim the same principles underlying their ethical judgment, their ethical intent and consequent behaviour: in fact, they also act out of respect for their reproductive autonomy and to protect Kate's integrity. By following the ethical deliberation path of these characters, as if we were them, not only do we feel the urgency to reach a decision, but we also perceive the situation as ethically challenging due to the moral intensity conveyed by the literary text. We also become aware of the fact that principles and theories are only meaningful when they are located in time and place, affecting the lives of subjects whose deliberation procedure is supported or weakened by individual and social circumstances. Not every route is ethically permissible, but there is surely more than one path that can be followed when deliberating upon controversial ethical issues.

The novel's adaptation to the cinema (directed by Nick Cassavetes, written by Jeremy Leven and distributed by New Line Cinema, Warner Bros. Pictures) has worked as the search for a different perspective of the deliberation process on the ethical issues of using PGD to have a saviour sibling and of knowing when to start palliative care. It is interesting to notice that the use of a different artistic medium has given back the mystery that vanished from the fictional text. In fact, the movie gives Kate the voice that the book does not let us hear and keeps both Kate and Anna in a constant tension. Therefore, Anna is portrayed as the one who keeps Kate alive and the one who helps Kate keep her dignity till the end. Death is present from the beginning of the novel and of the movie, but the former fights against it and the latter makes it part of the narrated lives of the characters, thus making them and the viewers aware of everyone's vulnerability. By keeping Anna alive at the end, the film argument introduces a significant twist in the story, which can be interpreted as an expression of respect for autonomy. It is this twist that makes us finally catch the magic eye picture: we can only see Kate from the background of the picture if we let Anna become visible; we can only see Anna when Kate is allowed to tell her own story; we can only see ourselves by narrating our own story to the *Other*, with and for the others:

> *Between the imagination that says 'I can try anything' and the voice that says 'everything is possible but not everything is beneficial (understanding here, to others and to yourself)', a muted discord is sounded. It is this discord that the act of promising transforms into a fragile concordance: 'I can try anything', to be sure, but 'here is where I stand!* (Ricouer, P. 1992, pp. 167-8)

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SCIENCE TEACHING METHODS AND SCIENTIFIC LITERACY: WHAT CAN WE LEARN FROM PISA 2006?

Jan Ardies
University of Antwerp
Institute of Education and Information Sciences
jan.ardies@ua.ac.be

Sven De Maeyer
University of Antwerp
Institute of Education and Information Sciences
sven.demaeyer@ua.ac.be

Wim Christiaens
University of Antwerp
Faculty of Political and Social Sciences
wim.christiaens@ua.ac.be

ABSTRACT

Regions with a strong knowledge-based economy need, now more than ever, their future generations to show a strong scientific literacy. Literature points to the importance of teaching methods in achieving strong scientific literacy; schools are essential in meeting this challenge. The current study, based on the the 2006 data of OECD's Program for International Student Assessment (PISA) focus on the effect of four different teaching methods on student scientific literacy. The study includes 3843 students from 151 schools in Flanders. Controlling for social background, gender and other student or school characteristics, the data are analyzed using multivariate multilevel regression analyses. The results show, surprisingly, that innovative classroom practices, such as class debates and the possibility for students to do their own investigations, have a negative influence on scientific literacy. Relating scientific topics to real situations and doing hands-on activities positively affected scientific literacy. Interest in science also increases when the content of the science lessons is put into a broader perspective. To conclude the results suggest that 15 year students profit the most from a teacher that focuses on models or applications in science and allows students to do hands-on activities.

Keywords: *scientific literacy, attitudes towards science, multilevel analysis, teaching methods*

INTRODUCTION

Knowledge-based economies, such as the Flemish region in Belgium, have a need for graduates with a strong scientific literacy. Therefore schools and teachers should embrace the most effective way of teaching science in secondary education. In 2006, PISA measured student outcomes in science. The results showed Flanders to be at the 8th place of all OECD countries for scientific literacy. Furthermore, PISA also assessed which didactical methods are used in the science lessons. These data create an opportunity to examine which teaching method results in strong student scientific literacy.

The current study is a secondary analysis of the PISA data and adds the connection between student outcome and the teaching method with control for different variables like gender, social status, language and origin, using a multivariate multilevel analysis on the student and school level.

The Flemish government of education determines final terms all students should reach. This is controlled by an inspecting committee but schools can choose the didactical method they use to reach the terms. Therefore we can expect significant differences in teaching methods.

THEORY

The last two decades, a lot of research has been done about educational effectiveness (e.g. Muijs & Reynolds, 2001; Creemers & Kyriakides, 2006). Effectiveness is defined as the degree in which schools succeed in obtaining their goals. For our study that is achieving a strong student scientific literacy.

Scientific Literacy

PISA defines scientific literacy as an individual's scientific knowledge and use of that knowledge to identify scientific questions, to acquire new knowledge, to explain scientific phenomena and to draw evidence-based conclusions about science-related issues. Also included in the PISA definition is understanding the characteristic features of science as a form of human knowledge and enquiry, and being aware of how science and technology shape our material, intellectual and cultural environments. Finally, for PISA, scientific literacy also includes the willingness to engage with science-related issues, and with the ideas of science, as a reflective citizen (OECD, 2007).

Scientifically literature students are able to deal with real life situations that involve science in a personal, social and global context. This ability to face such situations requires different competencies, such as identifying scientific issues, explaining phenomena scientifically and using scientific evidence. These competencies are influenced by knowledge and attitudes. Knowledge includes both scientifically content knowledge and knowledge about science.

The two attitudes in the PISA framework are: self efficacy in learning science and general interest in science. Those are directly related to goals of the European government (European Commission 2004) namely that more students study science and choose science as a career opportunity.

Teaching method

Creemers and Kyriakides (2006) describe which factors can enhance the effectiveness of schools. Their results point towards the teacher's instructional role, that was found to be consistently related to student outcomes. The quality of teaching and learning provision, supported by strategic teacher professional development matters most in affecting students' experiences and outcomes of schooling throughout their primary and secondary years (Rowe, 2003). Research on the determinants of high quality education shows that the teacher is the decisive factor (Barber & Mourshed, 2007). Constructivist learning theory, which was first described by Von Glasersfeld (1989), sees learning not only as an addition of information to existing knowledge but also as a reconstruction of what is already known. Learners are not a blank slate, and knowledge cannot be imparted without their making sense of it through a lens of their current conceptions. According to constructivism, children learn best when they are allowed to construct personal understanding based on experiences and reflecting upon those experiences. A constructivist classroom is characterised by students working in groups and learning as being interactive and dynamic; there is an emphasis on social and communication skills and on the exchange of ideas. In a traditional, nonconstructivist classroom, students work alone, learning is primarily achieved by repetition, and textbooks guide subjects.

Apart from the teacher's approach to teaching science, several factors are known to influence student outcomes, like school population, curriculum, social background, language spoken at home and gender. Also self efficacy in studying science and interest in science have been demonstrated to be of influence on student outcomes (OECD, 2006).

To examine the influence of the different styles of education it is necessary to control for school and student characteristics simultaneously in, using a multilevel approach (De Maeyer, van den Bergh, Rymenans, Van Petegem, & Rijlaarsdam, 2010).

School characteristics
Schools have been demonstrated to influence student outcomes (e.g. Hirt, Nicaise, von Kopp, & Mitter, 2007; Van Damme, Van Landeghem, De Fraine, Opdenakker, & Onghena, 2004; Veenstra, 1999).

A relation between average economic, social and cultural status (ESCS) from the school and the students outcomes can be expected (Veenstra, 1999; Van Damme, Van Landeghem, De Fraine, Opdenakker, & Onghena, 2004). The 2003 PISA data demonstrated large differences in student outcomes on mathematics in Flanders (Hirt, Nicaise, von Kopp, & Mitter, 2007). These differences can be partly explained by the school, and more specific by the school's cultural capital (Franquet, De Maeyer, & Kavadias, 2010).

Not only the quality of the lessons will have an effect, also the quantity is important (Creemers & Kyriakides, 2006). The actual time spend on science lessons has to be taken into account. When students choose a more scientific orientated study they will spend more hours in science class. Because the number of hours depends on the actual chosen study subjects and not on the educational track it is necessary to add the number of hours in the research model.

Student characteristics
Every pupil is different. They can differ in background, gender, language or others. Not all specific characteristics have an influence on school results. Social status, origin, language at home and gender are predictive indicators and are often used in school effectiveness research (Muijs & Reynolds, 2001).

Previous PISA research shows that economical, social and cultural status has an influence on students results (De Meyer & Pauly, 2007). In Flanders science achievement is higher than the OECD average, both for students with a low and high socio economic status. On the other hand the impact this status is bigger in Flanders than the OECD average (De Meyer & Pauly, 2007). In Flanders, students whose parents come from another country, score significantly lower than native students. The difference between both groups is also bigger than the OECD average (De Meyer & Pauly, 2007). Off course, the immigrant status is not the same has the language spoken at home. Therefore it is also necessary to take into account that students may speak another language at home than the language used to give instructions at school.

The difference between boys and girls in Flanders is not significant. Boys choose more scientific study options than girls, who prefer social studies. Because of this difference in choice some results hide a difference in science outcomes. The differences are usually bigger on school level than on region level (OECD, 2007).

RESEARCH QUESTIONS

1. Which constructivist science teaching methods have an effect on students science outcomes
2. What is the effect of a science teaching methods on students attitude towards science?
3. What is the effect of a science teaching methods style on students self-efficacy in science?

METHODOLOGY

Participants
This study reanalyzes the 2006 PISA data. PISA is initiated by the Organization for Economic Co-operation and Development (OECD) to study and compare student achievement. After a representative set of schools had been sampled in all countries, a random sample of 15-year-old students was drawn from each school. This study focuses on the 3843 students Flemish students from 151 schools who are studying general (ASO) and technical (TSO) education because these groups have a similar list of final terms in science and they had the same main curriculum at the first grade in secondary education. Both ASO and TSO are tracks which intend to lead to tertiary education; therefore the focus of this research is on this group of students.

Instruments
The PISA 2006 study was conducted as the third of the program's 3-yearly assessments of student knowledge and skills in mathematics, language and science. In the 2006 cycle, the focus of the assessment was on scientific literacy. In addition, students were administered a questionnaire assessing their background, learning habits, perceptions of their learning environment, and attitude towards science.

The research model:
The model used for this research is based upon the CIPO-model in combination with the PISA model for scientific literacy. The CIPO-model (Scheerens, 1990) refers to the importance of context, input, process and output. The output variables are knowledge and attitudes based on the PISA structure of scientific literacy. The teaching method is a process variable. School and students characteristics are the input and context items we integrate in our model as control variables.

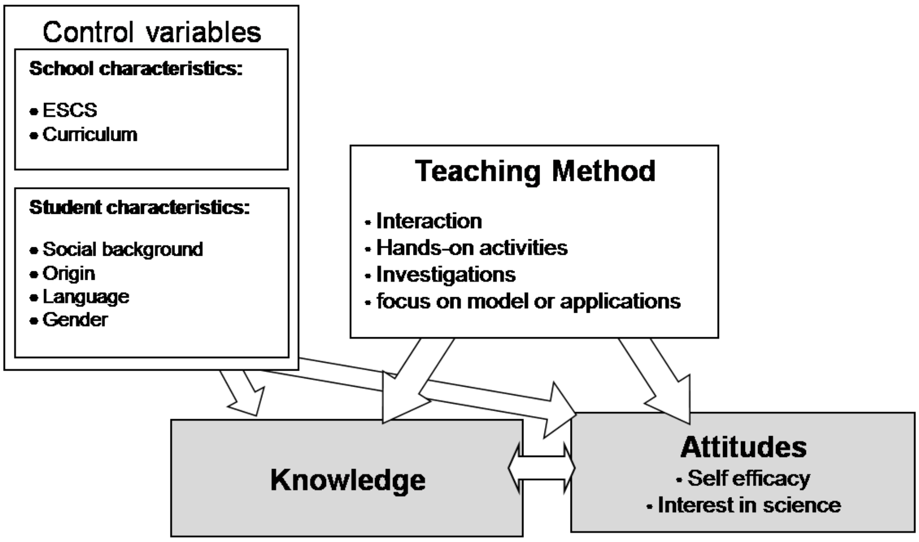

Figure 1: the research model

Variables
Three types of variables are included in our analysis: output measures on the one hand, and school and student characteristics as explanatory variables on the other. Unless mentioned otherwise, the variables described were used as they were constructed by PISA. All information on scale construction can be found in the PISA 2006 technical report (OECD, 2009). All non-categorical variables are standardized scores.

Scientific knowledge
Science abilities were measured by a 30-minute science assessment on knowledge of physical systems, living systems, earth and space, technology systems, scientific enquiry, and scientific explanations. The questions were distributed over items identifying scientific issues, explaining phenomena scientifically, and using scientific evidence (OECD, 2007). PISA 2006 reported five plausible values for science abilities, which were highly correlated (all $r(4,997) > 0.93$, $p < .001$). We selected plausible value 1 as a measure for science ability and computed a *z*-score for this scale using only the Flemish students.

Attitudes towards science
The index of general interest in science was derived from students' level of interest in learning eight different scientific topics. Examples are human biology, astronomy, requirements for scientific explanations, etc. A four-point scale with response categories from "high interest" to 'no interest" was used for the eight items scale (Cronbachs' alpha 0.82).
Self-efficacy was derived from the students' beliefs in their own ability to perform eight different tasks. Students could answer on a four point scale from "I could do this easily to "I couldn't do this" on questions like "Describe the role of antibiotics in the treatment of disease". These eight items have a high Cronbachs' alpha (0.80) for our analysis. None of the items needs to be excluded.

Explanatory variables, teaching method
PISA 2006 describes 4 science teaching methods: interaction, hands-on activities, student investigations and focus on model or application. These variables are based on 17 different questions. Students were asked to what degree four constructivist science teaching methods occurred. "When learning science topics at school, how often do the following activities occur?" was answered on a four range scale: 'in all lessons', 'in most lessons', 'in some lessons' and 'never or hardly ever' (OECD, 2007). The first variable on constructivist teaching methods is the scale 'interaction in science teaching and learning' (INTACT), indicating the frequency with which different elements of interactive teaching occur in their classroom. The INTACT scale has an acceptable reliability (alpha: 0.76). 'Occurrence of opportunities for scientific investigation' (INVEST, alpha: 0.73) and the 'Hands-on learning' (HANDS, alpha: 0.69) are constructivist teaching methods that are measured by the second and third scale respectively. The last scale for a constructivist science teaching method focuses the application of science to real life situations (APPLY) and shows acceptable reliability as well (alpha: 0.71).

Examples of different items according to this scales are:

INTACT: Interactions:

"The lessons involve students' opinions about topics."

HANDS: Hands-on activities:

"*Students spend time in the laboratory doing practical experiments."*

INVEST: Investigations:

"Students are given the chance to choose their own investigations."

APPLY: Focus on model or applications:

"The teacher uses examples of technological applications to show how science is relevant to society."

We included the constructivist teaching methods at the aggregated school level. Snijders and Bosker (1999) state that a scale's measurement error is reduced when a large number of respondents are included at the lowest level (as in our study n=3843). The large number increases the reliability of the estimate at school level. Moreover, as underlined by Griffith (2002), the appropriate level of analysis (at student or school level) is variable-dependent. When concepts measured at the individual level are nearly identical to concepts aggregated at the higher level (like 'Quality of instruction') the reliability can be assumed greater (Griffith, 2002). Therefore, the mean on each of the four scales for constructivist teaching was calculated for each school. Afterwards, each of the four scales were standardised at the Flemish school level. A positive score on for example ‘hands-on learning’ indicates that, in that school and according to the students, science is taught in a more hands-on way than in the average school.

Control variables

ESCS. The economic, social and cultural status (ESCS) of the student is composed by PISA from aspects like home possessions, highest occupational status and educational level of the parents. This variable is included both at the student level and aggregated at the school level.

CURRICULUM. An indicator for how much time students actually spent on regular science lessons. We reduced the original 5-point Likert scale from PISA to a 3-point Likert scale. The categories “none” and “less than 2h” are rescaled in a new category “few”. The category “2 to 4h” now is called “average” and the categories “4 to 6h” and “more than 6h” are composed to “much”. When these categories were reduced, we controlled that each category had an approximate equal number of respondents.

ORIGIN. Native students are born in Belgium, and so is at least one of their parents, Second generation immigrants are born in Belgium but their parents aren’t, and first generation immigrants are born in another country and so are their parents.

GENDER. A dummy variable singling out the girls in the data

LANGUAGE. Language is an individual variable because the terms used at school are often different than the register used at home. This is particularly difficult for students with an different language spoken at home (Trudgill, 2003). We only use the categories ‘same language spoken at home as during class’ and ‘different language spoken at home’. We don’t make a separation based on languages.

Analysis

This study can be divided in three main steps. First we will examine the intra class correlation between the two levels, school and student. This will be done with a basic model. Secondly we add the explanatory variables in a gross model to see what their impact is on the three outcome variables. And finally we add all control variables with school and student characteristics to control which factors at the school and student level explain variation in the outcome variables.

RESULTS

As explained in the methodology we will describe the results step by step starting with the basic model.

From the first model of the multivariate multilevel analysis (table 1) we can conclude that the variance for self-efficacy can be found for 7% at school level. Nearly the same can be said about interest in science where we find 8% at school level. This may not come as a surprise because both these variables are attitudes which are often personal aspects. So it is clear that variance can be found mostly at student level. For scientific knowledge the analysis shows that school level describes 38% of the variance. All variances are significant. We can conclude that schools matter a great deal when it comes to knowledge about science and scientific knowledge.

Self-efficacy and knowledge correlate rather strong and significant on school level (.760). So apparently schools where pupils score high on average for self-efficacy are more likely to score well on average for scientific knowledge too. Self-efficacy and interest in science have a medium correlation of .55 also at school level. All other correlations at school or student level are smaller.

On student level, high scores on one of the three variables don't necessarily go along with high scores on the other variables. A student can be highly interested in science, without having a large scientific knowledge. This means that the three dependent variables all measure some independent characteristic from scientific literacy.

Table 1: Estimated parameters first model (*correlations are italic*; variances bold*)*

School level	Self-efficacy	Interest	Knowledge
Self-Efficacy	**0.068**	*0.553*	*0.760*
Interest		**0.077**	*0.378*
Knowledge			**0.392**
Student level	Self-efficacy	Interest	Knowledge
Self-Efficacy	**0.935**	*0.354*	*0.394*
Interest		**0.925**	*0.156*
Knowledge			**0.644**

In our second model we add the four different science teaching methods (table 2). The results show 'investigations' has a significant negative relationship with self-efficacy and knowledge. This means that students from a school where there are more than average possibilities to do their own investigations in science, design their own experiments and test out their own ideas they score less than average on the topic knowledge. The same effect can be found when students have the opportunity to interact during science lessons. Discussions, class debates, and explaining their ideas too are significant negative for their science knowledge.

Hands-on activities like doing experiments or drawing conclusions from an experiment on the other hand are significantly positive for both self-efficacy and knowledge and can be seen a good style of teaching for achieving more scientific literacy. The same conclusion can be drawn for schools in which teachers who explain phenomena, use science to help students to understand the world and explain the relevance for science to our lives. Schools in which teachers that focus on models or applications in science not only have students with more self-efficacy and knowledge but also interest in science. This teaching method seems to be the only one who has a significant positive effect on interest in science.

Table 2: Estimated parameters and standard errors (S.E.) from the fixed part in the gross model

	Self Efficacy			Interest			Knowledge		
	Estimated	S.E.		Estimated	S.E.		Estimated	S.E.	
CONS	-0,012	0,023		-0,007	0,027		-0,042	0,037	
INVEST_mean_school	-0,100	0,031	*	-0,028	0,035		-0,271	0,047	*
INTACT_mean_school	-0,048	0,028		-0,014	0,032		-0,210	0,043	*
APPLY_mean_school	0,076	0,027	*	0,101	0,031	*	0,175	0,042	*
HANDS_mean_school	0,085	0,030	*	-0,013	0,034		0,161	0,047	*

* = significant at the p<0.05 level

When we look at the random part (table 3) we see that the correlations between the dependent variables are smaller in this model compared with the first one. There is still a strong positive correlation between self-efficacy and interest and between self-efficacy and knowledge. At student level these correlations are medium positive.

Table 3: Estimated parameters gross model (*correlations are italic*; variances bold*)*

School level	Self-efficacy	Interest	Knowledge
Self-Efficacy	**0.039**	*0.511*	*0.573*
Interest		**0.066**	*0.298*
Knowledge			**0.168**
Student level	Self-efficacy	Interest	Knowledge
Self-Efficacy	**0.935**	*0.354*	*0.395*
Interest		**0.925**	*0.156*
Knowledge			**0.644**

In the last model we add all student and school characteristics. The curriculum matters for all three dependent variables. Overall we can say that the number of hours of science has a positive impact on self-efficacy, interest and knowledge. This seems to be a logical conclusion because students who like doing science more often choose scientific studies than others and they feel more confident in studying science which will lead to a bigger self-efficacy.

The economic and social status of the student also has a positive influence on self-efficacy and knowledge but is not a significant predictor for interest in science. Schools with higher than average ESCS-score also have a positive effect on self-efficacy and knowledge, but not on interest. Interest is a very personal aspect which has no relationship with social background or school.

Second generation immigrants have a lower score in knowledge than first generation and native students. First generation students seem also to have more self-efficacy than both other groups. For interest in science there are no significant differences.

Students that speak another language at home than in the classroom, show a large and significantly lower score on knowledge. For interest and self-efficacy, the language spoken at home has no significant effect.

Girls score significantly worse than boys on all three dependent variables but the effect is twice as big on self-efficacy and knowledge as on interest. Probably self-efficacy is more related to gender than the style of teaching as we can see that girls have a significant lower score (-0.272 SD) than boys. Girls also seem to be less interested in science than boys (-0.125 SD) and they score 0.263 standard deviations lower on knowledge.

Table 4: Estimated parameters and standard errors (S.E.) from the fixed part in the net model

	Self Efficacy			Interest			Knowledge		
	Estimated	S.E.		Estimated	S.E.		Estimated	S.E.	
CONS	0,189	0,034	*	0,055	0,039		0,243	0,037	*
INVEST_mean_school	-0,055	0,029		-0,014	0,036		-0,189	0,039	*
INTACT_mean_school	0,000	0,026		0,015	0,033		-0,094	0,036	*
APPLY_mean_school	0,044	0,024		0,083	0,030	*	0,117	0,033	*
HANDS_mean_school	0,045	0,027		-0,033	0,034		0,094	0,037	*
CuSmall	-0,263	0,039	*	-0,178	0,040	*	-0,351	0,032	*
CuLarge	0,175	0,040	*	0,201	0,042	*	0,213	0,033	*
ESCS_school	0,168	0,060	*	0,052	0,076		0,420	0,082	*
ESCS	0,071	0,017	*	0,032	0,018		0,084	0,014	*
Or2nd	0,191	0,119		0,220	0,123		-0,391	0,098	*
Or1nd	0,291	0,135	*	0,123	0,139		-0,209	0,110	
Language	-0,085	0,088		0,020	0,091		-0,383	0,073	*
Girl	-0,272	0,033	*	-0,125	0,035	*	-0,263	0,028	*

* = significant at the p<0.05 level

After having controlled for student and school characteristics the correlation between self-efficacy and knowledge is only half of what is was before at school level. The curriculum has a strong effect on the self-efficacy, this explains why the correlation between self-efficacy and knowledge becomes smaller in the more advanced model. The correlation at school level between self-efficacy and interest remains more or less unchanged. At student level all correlations are the same as before.

Table 5: Estimated parameters net model *(correlations are italic;* variances bold*)*

School level	Self-efficacy	Interest	Knowledge
Self-Efficacy	**0.021**	*0.515*	*0.267*
Interest		**0.057**	*0.307*
Knowledge			**0.092**
Student level	Self-efficacy	Interest	Knowledge
Self-Efficacy	**0.858**	*0.335*	*0.365*
Interest		**0.893**	*0.137*
Knowledge			**0.554**

CONCLUSION AND DISCUSSION

Although this research revealed some interesting topics, some points of discussion can be made. Investigations need to be done to explore if this results are equal for all secondary students. It is likely to think that students who have more scientific background will be able to discuss some topics and design their own experiments. Different topics within science education can also be investigated on their own. Geography and physics might need an other approach than biology and chemistry.

The results show none of the science teaching method to have a significant effect on self-efficacy after control for student and school characteristics. Student interest in science, is after control for school and student characteristics, positively influenced by the teaching method ‘focus on models or applications’. Schools in which teachers explain how a scientific idea or subject can be applied to a number of different phenomena or they explain the relevance of scientific concepts for our daily lives, have students that show a greater interest in science. Students are more interested in a subject when they know where it is useful for.

All four science teaching methods have a significant effect on the students’ knowledge about science and scientific knowledge, which is in line with previous research about teacher effect on student outcome (e.g. Creemers & Kyriakides, 2006; Barber & Mourshed, 2007).

When students can explain their ideas, discuss their opinions or have class debates they will score 0.1 standard deviations less than students who have an average amount of interaction during science lessons. The largest effect is the negative impact of student investigations. When students are allowed to design their own experiments, they can chose their own investigations or they can test out their own ideas valuable study time is wasted when we want to add knowledge to our children. The common factor in both these teaching methods is the big input students can have on the topic of the lessons.

When students can do more than average hands-on activities like practical experiments either with the help of the teacher or not, but always by his instruction, they have more chances to score high on knowledge. We can say that they learn more about science when something is actually done by the students. The largest positive effect is a teaching method that helps students to understand the connection between science in class and the world outside the school. When teachers explain the relevance of the different scientific topics this not only has a positive impact on their interest, as explained above, but also on their knowledge.

These findings support Van de Werf (2005) who concluded that children benefit from a structured education and a hierarchical structure of the syllabus. When students themselves have to set goals and find what they are supposed to learn this may not be as efficient as when the teacher does.

Our results suggest that 15 year old students can benefit from somebody explaining different scientific phenomena and their relation to daily practices, the results also suggest that they might gain more science knowledge by following an instruction and doing an experiment which is set up by the teacher. Probably the scope of possibilities in science of 15 year olds is not broad enough to explore the scientific jungle by themselves. They need a guide to lead them to the different interesting spots and keep them on the right path. When they start exploring alone they will do it superficially and not as accurate as with their teacher. Teaching methods do make a difference when science has to be taught.

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DEVELOPMENT OF PRE-SERVICE SCIENCE TEACHERS' VIEWS ABOUT NATURE OF TECHNOLOGY AND EFFECTIVENESS OF DILEMMAS IN TEACHING

Fatih AYDIN

Abant İzzet Baysal University, Science Education Department, TURKEY
fatihaydin@ibu.edu.tr

Mehmet Fatih TAŞAR

Gazi University, Science Education Department, TURKEY
mftasar@gazi.edu.tr

ABSTRACT

The purposes of this study were to determine how pre-service science teachers' views and concepts about the nature of technology developed and what was the effectiveness of using dilemmas in instruction. A mixed methods research was employed in this study with one group pretest-posttest experimental group design. The main study was conducted with the participation of 3rd year pre-service science teachers (N=41) during 2008 spring semester. Findings suggest that pre-service science teachers' views and concepts about technology were generally at the novice level before interactions with the researcher during the instructional period, but their views and concepts have changed positively afterwards. Pre-service science teachers' views about effectiveness of dilemmas in teaching the nature of technology showed that dilemmas were found to be "useful" and "effective" in teaching and learning such understandings related to the nature of technology and provided rich thinking experiences in that regard. Here we present various forms of data that were collected throughout the semester and an analysis with recommendations.

Keywords: Nature of Technology, Technology Education, Science Education, Pre- Service Science Teachers, Dilemma, Mixed Methods Research

INTRODUCTION

We live in a world in which technology has been developing rapidly. Technology has become a part of our life and it has enclosed every part of our environment. "Modern society is dominated by the use of technology. Citizens in countries across the world are increasingly exposed to technology in a variety of forms; biotechnology, chemical technologies, transport technologies, and information and communication technologies." (Sade & Coll, 2003). When all of these are taken into consideration, in order to form a strong future, countries are aware of the fact that their citizens need to be raised as individuals possessing literacy in science and technology. However, the way science and technology are taught, play a key role in terms of attaining the desired outcomes. The vision of Turkish Science and Technology Curriculum has been ambitiously set as "educating all students, whatever their individual differences might be, as scientifically literate individuals." It is hoped that science and technology literate citizens can understand relationships and interactions between science, technology, society, and environment (MEB, 2005, p.5).

Many people immediately associate "technology" with computers and internet rather than its functional definition of "changing natural world to fulfill our needs" (Rose & Dugger, 2003, p.1). Studies indicate that technology mostly reminds electronic things and it only involves such things (e.g. Volk & Dugger, 2005). In addition, for a long time, technology has been widely defined as "applications of science." However, today, by putting aside this traditional paradigm, researchers are questioning what technology is and how it interacts with science and the society in a much deeper level (de Vries, 1996).

Approximately 60% of the American society is regarding science and technology as same things (Rose & Dugger, 2003, p.3). There is an idea in the minds that there is a strict connection between science and technology. In popular media these words are being used inter-changeably (Barlex & Pitt, 2002, p.177). It is necessary to develop the assertion that the relationship between science and technology is not a fundamental identity but a historical process. This kind of a historical evaluation indicates that "in many instances technology directed the development of science, rather than the other way around" and that it is only during the last century that science and technology formed and maintained a close relationship leading to a merger in some cases (McClellan & Dorn, 2006, p.2). "When students understand the relationship between science and technology, they realize how science and technology affect each other, how they develop in a social context, and how they are used to increase people's life standards" (MEB, 2005, p.64).

"Nature of science and technology, understanding its interaction with society and environment, obtained knowledge, understanding, and abilities are required to be used by students in seeking ways of solution to the problems" (MEB, 2005, p.60). Technology education is a considerably new topic, which does not have wide research-based and good structured class application culture (Mawson, 2007). Jones (1997) emphasizes that literature in technology education is related with direct definitions, program topics and teachers' education.

DILEMMAS

There are some arguable definitions of dilemmas in the literature. Reber (1985, p.201) proposes that dilemmas could be defined as "facing of a person with two or more cases separated correlatively and none of them is completely rewarding or not conformed to each other". Although there is an interest of social psychology on dilemmas, there exist only a few studies using dilemmas (Hirsch, Bar-On & Chaitin, 2004). Kohlberg was the first among psychological researchers to use dilemmas in his own moral development research. Teaching with dilemma approach by using dilemma stories relies on Kohlberg's studies (1963, 1984, and 1996, as cited in Settelmaier, 2004). Utilizing dilemmas take time and if a teacher wants to use dilemma stories, s/he needs a good planning for timing, to relate other topics and the theme of a story (Settelmaier, 2004). "Dilemma-based learning is an approach to thinking that focuses on the use of dilemmas to develop an individual's thinking skills" (Wood, Hymer & Michel, 2008, p.3).

Pre-service science teachers' views about environmental and moral dilemmas were also evaluated in recent studies and prospective teachers' inadequacies on the topic were revealed (Arslan, Çiğdemoğlu, & Geban, 2010). Another study showed that learning by dilemmas has a positive impact on moral views about environment (Tuncay & Yilmaz-Tuzun, 2010).

PURPOSES OF THE STUDY

The purposes of this study were to determine development of pre-service science teachers' views about the nature of technology and effectiveness of using dilemmas in teaching. For this purposes, the following research questions of this study were identified.

1. What are pre-service science teachers' views about the nature of technology before and after the instructional period? Are there any differences?
2. What are the effectiveness of using dilemmas during the development of pre-service science teachers' views about the nature of technology?

3. What are pre-service science teachers' views about effectiveness of dilemmas in teaching the nature of technology?
4. What are the implications for science teacher education?

METHOD

In this research, we used a one group pre-test post-test experimental group design (e.g. Johnson & Christensen, 2008; Cohen, Lawrence & Morrison, 2006) in which there was an instructional treatment including dilemmas. The reason of conducting research in a single group was that instructional treatment with dilemmas was done in lessons according to the topic context (topics about science and technology).

PARTICIPANTS

Before the main study, a pilot study was conducted with the participation of 4th year pre-service science teachers (N=41) who were enrolled in a Science-Technology-Society course during the 2007 fall semester, and the main study was conducted with the participation of 3rd year pre-service science teachers (N=41) who were enrolled a Nature of Science course during 2008 spring semester at a well-established teacher training faculty in a metropolitan city of Turkey.

INSTRUMENTS

In order to determine participants' views about the nature of technology before and after the instruction different data gathering instruments were utilized: The Views on Technology Questionnaire (VOTQ), interviews, and student KWHL entries.
The Views on Technology Questionnaire (VOTQ):
Participants' views about nature of technology were investigated by using VOTQ before and after the instruction. In order to construct VOTQ, 16 items related to technology were selected from Views on Science-Technology-Society (VOSTS) questionnaire improved by Aikenhead, Ryan and Fleming (1989). These items can be grouped into four categories related to:
1. Defining technology, (1st, 2nd, 3rd, and 4th items)
2. Effect of society on technology, (5th and 6th items)
3. Effect of technology on society, and (7th, 8th, 9th, 10th, 11th, and 12th items)
4. Social structure of technology (13th, 14th, 15th and 16th items)

In addition, in order to assess the participants' views, we used the same categorization system of views (namely informed, has merit, and naive) that exists in other related studies (e.g. Rubba, Bradford & Harkness, 1996; Tairab, 2001; Erdoğan, 2004). A panel of 7 experts and 3 researchers served to categorize the views about each item in the instrument (for the details of categories of each item see Aydın, 2009). VOTQ was adapted by using back translation method (Maneesriwongul and Dixon, 2004). VOTQ was translated from English to Turkish then from Turkish to English and was matched by two field experts and was controlled grammar by two field experts before asked participants. So, content validity of the adapted instrument was provided. Also, VOTQ was applied to 41 participants taken in pilot study in the first sense. As a result of the applications, the answers given by 42 participants to questionnaire including 16 items were analyzed. According to this analysis, among 656 (16x41) answers, merely 15 answers (2.28%) included one of the three choices which is repeated in all items of the questionnaire. This proportion is considerably lower than the proportions in literature (Rubba et. al., 1996 [10.03%]; Lieu, 1997 [5.93%]). Therefore, it was decided that this questionnaire could be used in evaluating the view of teachers on nature of technology. VOTQ was analyzed for each participants' views such as informed, has merit, and naïve (see Table 1).

The Interview protocol

Interview questions involved 8 semi-structured questions on nature of technology. Additionally, at the end of the interview, 3 semi-structured questions for determining participants' views about using dilemmas were used. The purpose at this point is taking participants' views on the effectiveness of the application (teaching) with dilemmas, the format of the lesson done with dilemmas, and the characteristics of dilemmas. Interviews were analyzed descriptively into seven categories that were identified from literature and participants' views.

KWHL entries

The acronym *KWHL* comes from "What I **K**now? What I **W**ant to Know? **H**ow I Will Learn It? What I **L**earned?" A chart containing a column for each of these questions is used to keep a record of participants' track of learning. Participants were asked to evaluate their learning process and the place of dilemmas during the semester. The KWHL data were analyzed descriptively and the same categories in the interview protocol analysis were used.

Dilemmas

Dilemmas were utilized during instruction as a teaching tool for raising awareness about issues related to the nature of technology. The dilemmas were composed of about 350 words and contained hypothetical scenarios with opposing views about the nature of technology such as usage decisions regarding a new technology (for the details of two opposing views of each dilemma see Aydın, 2009). At the same time while creating the dilemmas the following issues were taken into consideration: defining technology, defining technological literacy as a teacher, the effect of technology on society, the effect of society on technology, the social structure of technology, the relationship between science and technology, views about scientists and inventors, the characteristics of technology and technology education. Cases in which these topics could be discussed were constructed in dilemmas. As a result, 9 dilemmas were constructed and each week one dilemma scenario was used.

The instructional practice with dilemmas

Each dilemma was used during a 1.5 to 2 hours class period. Learners were encouraged to participate and contribute to the discussions. They were asked to discuss and support one of the two opposing views, constituting the dilemma, about the case. During and after the classroom discussions it was often seen that some students crossed the border to the other side and at the end they supported the view opposite to their initial views. It was emphasized that the fundamental aim was not advocating one "*true*" view about technology but rather the aim was, through discussions, to determine what the dilemma implies and explains about the nature of technology.

FINDINGS

FINDINGS FROM VOTQ

Table 1. Frequency of participants for each item from VOTQ.

		Categories					
		Naive		Has Merit		Informed	
Item Number	VOTQ Items	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
1	**10211** Defining of technology	14	7	11	23	15	10
2	**10311** Meaning of research and development	2	1	27	20	11	20
3	**10411** Relationship between science and technology	2	2	4	4	35	34
4	**10431** Relationship between science and technology	19	9	17	19	4	11
5	**20511** Effect of society on science and technology	3	2	--	--	37	38
6	**20521** Effect of society on science and technology	1	--	2	1	38	40
7	**40221** Relationship science, technology and moral decisions	20	16	10	5	11	19
8	**40231** Relationship science, technology and legal decisions	5	4	4	4	31	33
9	**40311** Trade-offs between the positive and negative effects of science and technology	12	7	9	10	18	24
10	**40413** Relationship science, technology and social problems	2	--	10	7	29	34
11	**40511** Effect of science and technology on society	--	--	22	22	19	17
12	**40531** Effect of science and technology on society	8	5	4	2	28	34
13	**80111** Usage decisions regarding a new technology	7	5	10	6	24	30
14	**80122** Usage decisions regarding a new technology	24	11	7	10	10	20
15	**80133** Usage decisions regarding a new technology	1	--	26	25	13	15
16	**80211** Control of technological developments	--	--	24	15	17	25

When pre-test and post-test findings are evaluated, it is seen that in 9 of the 16 items (namely items 2, 4, 7, 9, 10, 12, 13, 14, and 16) there is a big shift while in 4 of the remaining ones (items 5, 6, 8, and 15) there is a small shift in favor of the post-test. However, in two items (items 3 and 11) there is no gain.

When we examine these items under 4 main conceptual schemes (Aikenhead and Ryan, 1992), we reach the following findings:

1. Defining Technology (items 1, 2, 3, 4): Significantly improved student views.
2. Effect of society on science and technology (items 5 and 6): Since there was not much room for improvement, the results show a rather steady tendency in views.
3. Effect of science and technology on society (items 7, 8, 9, 10, 11, 12): It is seen that whenever there is much room for improvement some progress was achieved although there is still a need for progress.
4. Social structure of technology (items 13, 14, 15, 16): Significantly improved student views whenever possible.

FINDINGS FROM INTERVIEW AND KWHL ENTRIES

In this section, the findings from face to face interviews and KWHL entries with participants are presented. In order to be able to present the findings altogether, they are given in categories. When the participants' views are examined, it is seen that the post instructional views are more compatible with the desired outcomes as compared to the initial views.

A) The Views on the Definition of Technology
Participants views before the instruction were in parallel with the naïve views as determined by experts in VOTQ and also in parallel with the weak views that are in the related literature. For example:

"Technology always reminds me computers directly but I mean many electronic devices, etc." **(Excerpt 3, I. Interview S12, line 11–12, before instruction)**
"I think that technology is the application of science." **(Excerpt 151, KWHL S39, line 5–6, before instruction)**

After the instruction, it was seen that there was a shift towards strong views labeled as "has merit" and "informed" For example: "To me technology is the inventions that make people's lives easier and increase their life standards." **(Excerpt 4, II. Interview S12, line 6–7, after instruction)**

"I learned that technology is not only the application of science but it is also interwoven to science." **(Excerpt 152, KWHL S39, line 43–44, after instruction)**

B) The Views on Technology Literacy
Participants views before and after the instruction were close to each other but also the post-instructional views were more parallel to the desired views in literature. For example: "[Individuals] should closely follow the technological developments, I mean the new things. [Individuals] should use those in their daily lives, I mean make use of them." **(Excerpt 27, I. Interview S9, line 29–30, before v)**

"Surely trying to use them is important to some degree but it is also important to have knowledge about it. Not only how to use it, but also how it works…" **(Excerpt 28, II. Interview S9, line 24–26, after instruction)**

C) The views on the Nature of Technology (Its features, qualities etc.)
Participants views before the instruction were in parallel with naïve views as determined by experts in VOTQ and also in parallel with the weak views that are in the related literature. But after the instruction they had views parallel to the "informed" views. For example: "I think technology can be created by using sciences like mathematics." **(Excerpt 49, I. Interview S9, line 73, before instruction)**

"Before taking this course I was not thinking that there could be negative sides of technology also." **(Excerpt 164, KWHL S28, line 5–6, before instruction)**

"In the end it [technology] advances by accumulation. For example a tool can be improved, I mean once a tool is invented they can be developed further, they can be taken advantage of …" **(Excerpt 50, II. Interview S9, line 42–44, after application)**

"I learned that when presenting technology first of all its design is very important, it should be affordable and its marketing needs to be planned in advance before it is presented." ***(Excerpt 175,* KWHL *S3, line 30–32)***

D) The Views on Relationship Between Science and Technology
There is a shift fro naïve to informed views. For example:
"Seems to me that as if both are advancing by relying on each other. At some point, as if, they are receiving support from each other." **(Excerpt 63, I. Interview S12, line 66–67, before application)**

“Before coming to this course I was thinking that technology was emerging out of science. I did not know how science and technology were related.” **(Excerpt 182, KWHL S28, line 13–15, before application)**

“Neither of them can be imagined separate from the other. By using scientific knowledge, technological stuff are being produced. For example when hammer was invented no science was applied but now there are parts onto which science is applied.” **(Excerpt 64, II. Interview S12, line 63–66, after application)**

“These disciplines were born and advanced independent of each other. However, today, science makes up the infrastructure of technological developments, and on the other hand technological developments support scientific findings and research.” **(Excerpt 183, KWHL S41, line 83–85, after application)**

E) The Views on Effect of Technology and Society Mutually
While participants could not put forward any views on this topic before the instruction, after the instruction they had views that are labeled as “has merit” and “informed”. For example: “Both are influencing each other but I do not have any idea as to what degree they influence each other.”

(Excerpt 81, I. Interview S34, line 115–116, before application)
“There are aspects of technology that increases the life standards. For example, we can find everything in the internet. Ultimately, as long as society does not accept, a technology cannot develop or gain common ground.”

(Excerpt 82, II. Interview S34, line 38–40, after application)
“I learned that there are the influence of social values, ethical values, and the factor of religion on science and technology.” **(Excerpt 199, KWHL S18, line 25–26, after application)**

F) Views on the Characteristics of Inventor and Scientist
When participants’ post instructional views are examined it is seen that they could make a better discriminate between scientists and inventors, and realize that inventors do not necessarily have to posses scientific knowledge. For example: “I used to think that inventors had to have theoretical knowledge about the inventions that they make.” **(Excerpt 206, KWHL S33, line 6–7, before instruction)**

“Scientist is a different concept than inventor… An inventor does not have to have scientific knowledge. He can produce things by his experiences, put forth practical benefits.” **(Excerpt 120, II. Interview S17, line 120–122, after instruction)**

G) The Views on Technology Education
The post instructional views of the participants were reflecting more understandings and were closer to views labeled as “has merit” and “informed”. For example:
“It’ll make our job easier to give to the interested ones [students]. Since s/he will be more attentive we will develop more quickly.” **(Excerpt 133, I. Interview S12, line 139–141, before instruction)**

“Everybody should receive education. Technology is bringing states to higher levels. For example, although the production cost of mobile phones is not that much we are paying a lot of money for them. In this way other countries are earning.” **(Excerpt 134, II. Interview S12, line 147–149, after instruction)**

“I’ve learned that it will be more effective if science and technology are taken together with education. This education should be given to all segments [of the society].” **(Excerpt 210, KWHL S32, line 39–40, after instruction)**

FINDINGS RELATED TO THE EFFECTIVENESS OF DILEMMAS IN TEACHING

It is seen that participants have generally positive views towards the questions on the advantages, disadvantages and the different point of views formed in themselves of the instruction given with dilemmas.

“The advantage was that we realized at least that that there was two ends of technology…” **(Excerpt 211, II. Interview S1, line 8–12)**

“In this way everyone was able to get information from each other when we were supporting opposing views and there were many interpretations and comments.” **(Excerpt 213, II. Interview S34, line 12–15)**

When the participants’ views on the form of using dilemmas in teaching nature of technology are examined, it is perceived that there are generally positive statements.

“I think this was a very nice and useful course. I mean after the issue was given we had a question mark in the head and that remained as a question mark throughout the week to think.” **(Excerpt 219, II. Interview S41, line 20–25)**

When the participants’ views on dilemma’s, like their interesting aspects are examined, its examples and its compatibility with scenario, positive findings are obtained.

“I mean where the story was heading was interesting, when we say something and when you lead us into other directions to think, different things were coming out.” **(Excerpt 225, II. Interview S17, line 48–50)**

“Dilemmas have an undeniable power to attract students’ attention. They are useful in that they provide opportunities to see different factors and to reanimate various elements in the mind.” **(Excerpt 228, II. Interview S41, line 64–68)**

When the participants’ views to the question of “What was the effect of lesson on my learning?” are examined, it is enabled to the idea that the application was considerably effective in learning.

“Thanks to this course we were able to see that many concepts we knew were wrong and had an opportunity to change them with the correct ones.” **(Excerpt 229, KWHL S8, line 87–89)**

“We were, certainly never, given a chance to think like a scientist. To be in her/his place. In this course you created thoughts like that.” **(Excerpt 232, KWHL S20, line 27–29)**

DISCUSSION AND CONCLUSION

NATURE OF TECHNOLOGY

It is showed that findings by different data collecting instruments on nature of technology are similar. When participants' views are examined before the applications, they generally define technology as the application of science and fulfilling the needs. This result is compatible with many studies and literature (e.g. de Vries, 2005; p.2; Yalvaç, Tekkaya, Çakıroğlu & Kahyaoğlu, 2007). However, when the participants' views are evaluated after the applications, it is seen that most of them has been far from the idea defining technology as an application of science. Similar issues are also contained in the views on the purpose of technology after the applications. The detections of participants towards the purpose of the technology are also similar in literature (e.g. MEB, 2005).

It is seen that participants' views before the applications on the relation between science and technology is compatible with literature (e.g., Rose and Dugger, 2003, p.3; Yalvaç et al., 2007). While participants thought science and technology as non-separable and claimed that there could be no technology without science before the applications, in contrast, they stated that science and technology progress separately; technological product could emerge without science and this issue should be examined from the historical account after applications. Also, many points related with nature of technology in literature (Technology Education Centre, 2008; ITEA, 1996, p.16) are compatible with the ideas of participants after the applications. For example, participants were not aware of the negative effects of technology before applications as it is also proposed by de Vries (2005; p.107). Similarly, as designated by Solomon (1997, p.155), new technologies as a result of the applications changing the lives of people both in expected and unexpected way are encountered as an issue also cognized by participants. However, it is seen that participants give a great place to the relation of technology with moral values in their views on the effect of society on technology after the applications. In this frame, it is perceived from the participants' views that although technology has an effect on society, society has also an effect on technology.

When we evaluate the findings from VOTQ as a result of the applications done with dilemmas, the participants' views after applications is more meaningful with respect to their views before applications. Besides, according to the interviews with participants and the ideas of experts, many items belong to questions in the questionnaire is inadequate in the sense of statement and explanation. As an illustration, the interviews with participants explain the case better in the topics of the definition of technology, the relationship between science and technology, technology education and the issues of technology. This result clearly states that the questionnaire should be supported by interviews in order to obtain more clarified data. This case requires that there should be more developed questionnaire prepared about nature of technology.

EFFECTIVENESS OF DILEMMAS IN TEACHING

The results reached in this research indicate that dilemmas have many advantages in teaching nature of technology more effectively:

1. It is important to become aware of the fact that at least two opposing views can be regarded.
2. Discussing opposing views with learners can create many vivid and sound examples.
3. Emerging different perspectives and comments support rapid information transfer and hence increase the effectiveness of instruction and participation to lessons.
4. Dilemmas increase people's curiosity and make people more willing to do research.
5. Dilemmas create question marks in the mind, which in turn creates interest to learn. This stabilizes the person in the argumentative state for a longer period of time.

6. The “open-endedness” in dilemmas are influential in creating different topics and aspects of technology.
7. Dilemmas create opportunities to think and somewhat behave like a scientist.
8. Dilemmas can promote multi-dimensional thinking, learning to draw meanings, and forming own ideas.

The results obtained by this research indicate that dilemmas have also a few disadvantages which can be summarized as follows:

1. Learners have a tendency to know certain results rather than adopting critical approach. The fact that dilemmas, by their nature, have two opposite poles can cause negative reactions by putting the learners in conflict.
2. Learners emphasize that they have difficulties with this instructional approach because they are not used to reaching the conclusions by themselves.

When we take above advantages and disadvantages of dilemmas into a consideration together, while using the dilemmas in science and technology education the following guideline can be followed for a better instruction:

1. In order to prevent negative reactions it is important to promote critical thinking first. Topics can be assigned one week before in order to encourage the learners to think critically in advance.
2. It is also necessary for learners to be prepared for the topic to be discussed by gathering information from different resources and becoming ready for discussion by considering a wide variety of views about the topic. In this study, it was seen that one week was usually enough for preparation.
3. Having enough time for discussion is important. Although some participants have different ideas about allocation, they generally state that time between 1.5 - 2 hours is enough for them.
4. Teacher guidance is important for teaching by dilemmas. If teacher guidance and support is not sufficient, the discussions can be distracted far away from the topic.
5. Different presentation devices and/or materials can be allowed and used.
6. Having several concrete examples supporting opposing poles of the dilemmas can be appropriate and useful for students to understand the topic.

In sum, the findings from the pre and post instructional data shows that instruction with dilemmas had a positive effect on participants’ learning of the nature of technology. This supports the findings of the previous studies (e.g. Compton & Harwood, 2003, Jones & Moreland, 2003) that if opportunities are provided for students to develop their understanding of nature of technology in an increasing and sophisticated way, their learning of technology generally increases.

Similarly, as indicated by de Vries (2005), in teaching and learning of technology, it is important to develop the understandings and points of views about technology with different teaching strategies. In order to help learners understand these aspects of technology, it is necessary to encourage them to think by themselves in detail while developing their own perspectives. As the above cited literature assert, dilemmas also provide opportunities to learn the various aspects of technology and encourage them to discover new understandings individually and foster their own points of views. Hence, we stress that dilemmas can be utilized effectively in teaching the nature of technology but they can be improved and adjusted according to the teaching and learning needs.

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THE IMPACT OF HANDS-ON ACTIVITIES IN 6TH GRADE "ELECTRICITY IN OUR LIVES" UNIT ON STUDENTS' ATTITUDES

Nurcan AYDIN
Teacher

Beril Salman AKIN
Asisst. Prof. Dr., Gazi University
bsakin@gazi.edu.tr

Ezgi GÜVEN
Research Asisstant, Gazi University
ezgiguven@gazi.edu.tr

Elvan İNCE AKA
Research Asisstant, Gazi University
elvanince@gazi.edu.tr

Mehmet Fatih TAŞAR
Assoc. Prof. Dr.,
Gazi University mftasar@gazi.edu.tr

ABSTRACT

The Turkish primary science and technology curriculum has been recently reformed and based on the constructivist approach. The aim of this study was to examine the effects of the activities employed in the Electricity in Our Lives unit of 6th Grade Science and Technology curriculum on the students' attitudes towards science courses. The sample of this study was two different groups of 6th grade students attending a public primary school. The treatment group was taught according to the activities included in the new curriculum, and the control group was taught according to the traditional methods. In the study, a treatment/control group pre-test/post-test design was employed. The science course attitude scale was used for data collection. Independent and dependent t-test statistics were performed for the purpose of testing the sub problems of the study. The data analysis shows that there is no statistically significant difference between the treatment group and the control group. However, the results also showed that the attitudes of female students changed in a more positive way than that of male students.

Keywords: *Science and technology, Traditional Education Method, Attitude*

INTRODUCTION

Education is in constant development along with the changing circumstances of the world. For this reason, establishing new education environments, choosing right materials and methods for effective instruction of a course as well as determination of students' interests, attitudes and needs are very important in constantly developing education programs.

Today, instead of the textbook and teacher centered approaches, student centered approach is valued. In this way students can collect information from various sources and inquiry is a means of continued learning (Doğanay, 2000). Individuals who value development and innovation, fulfill their own duties, are needed in this ever changing world. From a constructivist point of view direct transfer emotions and knowledge to learners is not possible. In the student centered learning approach students are epected to create new knowledge on top of existing textbook knowledge. Learners take an active role in the process of creating of meaning by interpretation (Yıldırım & Şimşek, 1999).

All these facts led to fundamental changes in the curricula of various countries. As a result, student centered teaching/learning approaches are now dominant throughout the world (Osborne & Wittrock, 1983; Watts & Pope, 1989; Hand & Treagust, 1991). Similarly, many studies from Turkey and abroad were investigated. Results of these investigations reveal that cooperative approach have an important impact on students' attitudes (Bilgin & Geban, 2004; Veenman et al., 2005).

One of the most important aims of science education is to enable learners' development in affective fields. Learning acquired in affective fields involves the changes taking place in individuals with respect to such concepts as values, beliefs and attitudes. Values play a significant role in the formation of attitudes and beliefs (Simpson et. al., 1994). Values help individuals develop specific attitudes and beliefs as well as serve them as standards or decision making criteria for taking decisions (Rokeach, 1973).

The construct of attitude, which has a significant place in learning, has various definitions in the literature. While Senemoğlu (2000) defines the concept of attitude as an acquired inner condition that determines an individual's choices in his/her activities against any given group of people, individuals, events and various other circumstances. Gardner defines the attitudes towards science fields as "learned a priori inclination in the evaluation of objects, humans, actions and situations in specific ways" or "propositions regarding the learning science" (George, 2000).

When science education literature is examined it is seen that attitude has a great role in attaining meaningful learning. Given the fact that education is the primary means of attitude development and improvement, teachers knowledgeable about determining attitude measurement and assessment, both in their courses and in daily life, can be an important factor in improving the quality of education offered (Alkan and Ertem, 2004). Attitudes are about handling and controlling the emotions stemming during the learning process and they have a significant role in shaping humans' behaviors. Positive or negative quality of the attitudes formed in connection with a certain set of values and beliefs directly affects the learning process and thereby shapes the individuals' future lives (Seferoğlu, 2004).

There are two important reasons for researchers to conduct a study with respect to the students' attitudes towards science courses. First of all it is determined that the attitude towards science courses supports the students' behaviors, their course choices, quality and appropriate class works, participation in scientific researches and scientific studies (Koballa & Crawley 1985). Secondly, there is a correlation between students' attitudes towards science courses and their successes (Schibeci and Riley 1986). In their studies, Peterson & Carlson (1979) have stated that the change in the success level of the students is also the reason for the change in their attitude. Moreover, the results obtained from study conducted by Gürkan and Gökçe (2001) demonstrates a meaningful relationship between the students' successes and attitudes towards science courses. According to this relationship, the more positive an attitude a student adopts towards science courses, the more successful he/she becomes in such courses.

The activities included in science education arouse students' interests and lead them question as to their priorities and thereby perceive natural events from different angles. Most of the activities in science education help change attitudes in positive manner (Aydın & Balım 2005). When the students are encouraged to participate actively in science courses and concrete learning process is established, and when cooperative and project based learning approaches are employed, it is seen that such factors contributed positively on such cognitive and affective qualities as success, high level cogitation skills, social development, self-respect and attitudes (Fidan, 1996; Açıkgöz, 1992; Korkmaz and Kaptan, 2002).

This study examining the effects of Science and Technology Education Program, which was intended for 6th grades during the Academic Year 2006-2007 and that covers education activities aiming at teaching the students basic science concepts, scientific process skills, understandings regarding science, technology, society and environment as well as scientific values and attitudes, on the students' attitudes towards science courses is important in terms of shedding light to the future education programs to be developed.

PURPOSE

The main purpose of this study was to determine the impact of activities employed in the unit entitled “The Electricity in Our Lives", which is included in the 6th Grade Science and Technology Course curriculum that is intended for scientific activities based on "by doing and experiencing", on the students' attitudes towards science course. Also examined in the study was whether or not the attitude scores differed according to gender. The sample consisted of 6th grade students in a public school.

METHOD

In this study a pre-test/post-test design with treatment/control groups was employed. The dependent variable in this study was student attitude level scores as measured in the sixth grade “electricity in our lives” unit. The independent variables were the teaching methods employed and gender. The reason for selecting the “electricity in lives” unit was that it was previously determined as a difficult subject for students. Pine, Messer and John (2001) found that science teachers had expressed that primary school students had several difficulties in the “electricity” unit. Moreover, several other studies revealed that student in all levels from elementary to university years, have had misconceptions about electricity (e.g., Tianyu & Thomas, 1991; Chambers & Andre, 1997; Azar, 2001; Lee & Law, 2001; Sönmez, Geban & Ertapınar, 2001; Büyükkasap, Samancı & Dikel, 2002; Tsai, 2003).

Sixty four 6^{th} grade students attending two different schools in a small town in Kayseri province were the sample of this study.

The science course attitude scale was developed by the authors of this study. The attitude instrument is a 5 point Likert type scale consisting of 24 items. Out of those 24 items, 15 of them include positive statements, and the remaining 9 have negative statements. The reliability study of the prepared scale has been conducted on a total number of 134 6th grade students studying at other primary schools in the same town. The data were analyzed by SPSS 11.5 program and the reliability of the scale Cronbach α was found to be .84. 4 experts' opinions were taken for the validity of the instrument.

Before performing the study, the attitude scale was administered to both test and control group students as pre-test. The experimental study was conducted in both groups for 4 hours a week throughout a period of 3 weeks. At the end of the study the attitude scale has once again been administered to both groups as post-test.

The parametric dependent and independent groups t-test was used for data analysis. As a result of the statistical analysis, the significance level was determined to be .05.

FINDINGS

At the beginning of the study period, t-test results for independent groups, which has been used to determine whether there was a difference between the test group and control group students' attitudes towards science and technology courses at the meaningful level, has been given.

Table1 Independent Groups t-test Results of the Preliminary Test Points Regarding the Test and Control Groups Students' Attitudes towards Science and Technology Course

Groups	n	M	ss	sd	t	p
Test	32	95.31	11.87	31	-.962	.340
Control	32	98.06	10.96			

According to Table 1, there is statistically no difference at the meaningful level between the preliminary test points obtained in the attitude test at the outset of the study by test group students, who are trained according to the constructivist approach in the new science and technology course education program, and that of control group students, who are subject to the science education consistent with traditional education methods ($t_{(31)}$ = -,962; p>.05).

While, according to the data in the table, the average of the attitude points of test group students prior to the application was M = 95.31, the average of the attitude points of control group students prior to the application was M = 98.06. The finding of no statistical difference at the meaningful level between the attitude points of test and control group students at the outset of the application is considered to be consistent with the purpose in terms of determination of the effectiveness of the applied course activities.

Table 2 Independent Groups t-test Results of the Final Test Points Regarding the Test and Control Groups Students' Attitudes towards Science and Technology Course

Groups	n	M	ss	sd	t	p
Test	32	110.59	9.38	31	1.251	.216
Control	32	97.34	11.30			

According to Table 2, there is statistically no difference at the meaningful level between the final test points obtained in the attitude test at the end of the study by test group students, who are trained according to the constructivist approach in the new science and technology course education program, and that of control group students, who are subject to the science education consistent with traditional education methods ($t_{(31)}$= 1.251; p>.05). While, according to the data in the Table 2, the average of the attitude points of test group students after the application was M = 100.59, the average of the attitude points of control group students after the application was M = 97.34. The finding of no statistical difference at the meaningful level between the attitude points of test and control group students at the end of the application proves that the applied course activities do not affect the students' attitudes towards science and technology course at a meaningful rate.

Table3. Dependent Groups t-test Results of the Preliminary Test Points Regarding the Male and Female Students' Attitudes towards Science and Technology Course in the Test Group

Sex	n	M	ss	sd	t	p
Girls	15	99.66	11.67	30	2.046	.051
Boys	17	91.47	10.97			

As could be seen in the Table 3, there is no difference at the meaningful level between the attitudes of male and female students in the test group towards science and technology course at the outset of the science education process which is exercised with the activities of the new science and technology curriculum ($t_{(30)}$= 2.046; p>.05). Prior to the study, the average of the attitude points of the test group female students was M= 99.66 while the attitude point average of the male students was M=91.47. When those values are considered, there is no statistically meaningful difference between attitude points of the male and female students prior to the study. Finding of no meaningful difference between the preliminary test attitude points of the test group male and female students prior to the application is considered to be consistent with the purpose in terms of determination of the interaction between sex and attitudes.

Table 4. Dependent Groups t-test Results of the Final Test Points Regarding the Male and Female Students' Attitudes towards Science and Technology Course in the Test Group

Sex	n	M	ss	sd	t	p
Girls	15	104.73	8.58	30	2.541	.016
Boys	17	96.94	8.72			

According to the Table 4, there is a difference at the meaningful level between the test group male and female students' attitude towards science and technology course a result of the science education process rendered in accordance with the activities of the new science and technology course curriculum $t_{(30)}= 2.541$; $p<.05$). At the end of the study, while the average of the attitude points of the test group female students was M = 104.73, the average of the attitude points of the male students was M =96.94'tür. According to those values, there is a statistically meaningful difference in favor of female students between the attitude points of the male and female students at the end of the study. When the attitude points of the male and female students are observed at the end of the study, it can be remarked that the female students' attitude towards science and technology course has increased more than that of male students.

The male students' attitude towards the course has also increased, but not as much as that of female students. As could be understood from the aforementioned, sex determines the students' attitude towards the course.

RESULTS AND DISCUSSION

As a result of the findings gathered from the study, the following results have been obtained.

It is possible to summarize the results obtained as follows:

According to the findings of the study, there is no meaningful difference between the preliminary test attitude points of the test group being subject to the new science and technology curriculum and the control group being subject to the traditional education methods.

According to one another result obtained from the study, there is no meaningful difference between the post application attitude points of the test group trained in new science and technology education program and the control group trained in traditional education methods. According to this result, the activities included in science and technology curriculum do not increase the students' attitudes in a positive way. However when the final attitude points of the both groups are observed, it is possible to state that there is an increase in students' attitudes in favor of the test group students, although such an increase is not statistically meaningful.

All of the statistical results obtained from this study show that the course activities used in new science and technology course curriculum do not affect the students' attitudes towards the course at a meaningful rate. Thus the finding of no statistically meaningful difference between the final test attitude points of test and control groups supports this opinion. As a conclusion it can be said that the course activities prescribed in the new curriculum do not affect the students' attitudes in a statistically meaningful level. However, the attitude points of the test group students have slightly increased after the application. Despite the fact that such an increase is not statistically meaningful, it can be said that, based on the result achieved, the attitudes of the test group students towards science and technology course may develop in a positive way.

Previously conducted studies of the similar nature also support the results of this study. Bredderman (1983) compared the efficiency based programs against traditional programs and concluded that the difference resulting from the comparison, though not being meaningful, was clearly positive. In 400 comparisons made, 32% of the students liked efficiency based programs, and only 6% of them preferred traditional programs. Based on the results of the study, Bredderman (1983) concluded that if efficiency based programs was to be applied more commonly there could be a high probability of increase in the students' attitude towards science courses.

One another result obtained from the study was that sex was influential in determination of the test group male and female students' attitude who were being educated in accordance with the new curriculum. Female students' attitude towards science and technology course is more positive than that of male students.

When the attitudes of male and female students are observed, there is a meaningful difference in favor of female students. It can be said that the applied course activities increased the attitude of female students more than that of male students. Similarly, Yaman and Öner (2006) have found out in their study entitled "A Study Regarding the Determination of Primary School Students' Points of View Towards Science Course" that the attitudes of female students were more positive than the male students. However, in his experimental study where he studied the effects of constructivist teaching strategies on the high school students' attitude towards science courses, Heron (1997) found out that employment of constructivist teaching strategies had a positive effect on the students' attitude towards science courses and that eliminated the attitude difference between male and female students. Similarly, in a study it was revealed that secondary students' negative attitudes towards science and mathematics had changed according to gender and grade level (Koca and Şen, 2006).

In this respect, the results gathered in this study are important for shedding light to the future studies to be conducted in this area and mending the deficiencies inherent in the literature.

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NATIONAL ASSESSMENT OF KNOWLEDGE OF PHYSICS AND CURRICULUM DEVELOPMENT IN SLOVENIA

Jurij Bajc
University of Ljubljana, Faculty of Education, Slovenia
jurij.bajc@pef.uni-lj.si

Jerneja Pavlin
University of Ljubljana, Faculty of Education, Slovenia
jerneja.pavlin@pef.uni-lj.si

ABSTRACT

We present Slovenian national assessment of knowledge of physics at the end of elementary education as an example of a tool to assess the knowledge of the population. Changes and reforms of school systems follow one another in a quick pace – all in the name of adjustments to the development and new challenges of the mankind and in agreement with new research results on what is the best way of teaching specific topics to children of certain age (Black, 2000; Kelly, 2009). In order to measure success of reforms one has to assess the knowledge of selected age groups and follow the trends for years. We do not know the trends of Slovenian knowledge of physics yet, because we only have data for two years, 2007 and 2008, but several typical problems in 15 years old pupils' comprehension of physics and general lack of ability of solving non-standard questions seem to be common weak points of the population. How to incorporate these results in an always developing curriculum is a difficult task and we demonstrate why this is so by a few examples.

Keywords: physics, assessment of knowledge, primary school, curriculum.

INTRODUCTION

At present the curricula for nine-year primary education (age 6-15) in Slovenia are reforming again – new curricula were prepared in 2007, but there are some formal obstacles that are awaiting to be resolved. The valid curriculum for physics dates at 1998, so the initiative for changes appeared only seven or eight years after the last curriculum changes have been adopted. Is it reasonable to change curriculum so often?

On the other hand, there is close to 20 years of history of final exams after finishing primary education. From the results we may not be able to say, if the changes in curriculum are necessary or not, but we can surely say that we do not posses reliable data on why the knowledge of physics in Slovenia is such as it was measured. Several successive assessments of knowledge of a subject should be made before attempting to change the curriculum.

Although two decades of examining the pupils after finishing primary education seems a lot of data, it is not the case for, e.g., physics. Up to 2005 mathematics and mother tongue were tested each year, but the "third" subject was selected by the pupils. The results of the exams were the basis for entering secondary school. Out of around 20.000 pupils only less than 100 choose physics each year, so our assessment of knowledge of physics was neither representative nor accurate. Since 2006 the character of the test at the end of primary education changed from being selective into being an assessment tool for the population. There are still three subjects assessed, but the "third" subject is chosen by the Ministry of Education. Each year four "third" subjects are selected and the knowledge of each is assessed on a representative one quarter of the population – around 5000 pupils. Knowledge of physics was assessed in 2007 and 2008 and is expected to be reassessed in

2011. One of the reasons for the 2009 and 2010 gap is big coherence between the 2007 and 2008 results, so we did not expect detectable changes in a short time and have advised the Ministry not to repeat assessment right away.

In the present paper accumulative results of two successive national assessments of knowledge of physics after finishing primary school are presented. In both assessments many similar strong and weak points in the knowledge and understanding of physics are found. This gives reliable insight into the present level of knowledge of physics among Slovenian pupils at the end of the nine-year primary education when they are aged averagely 15. But, from the results we cannot determine why there are certain weaknesses in the concepts or why the pupils misunderstand certain laws of nature. We can only speculate about the reasons. In the paper we give a few examples of the questions that illuminate weak physics, but at the same time do not unequivocally give reasons for such weaknesses in terms of required changes in curriculum or at least in the way physics is taught.

In order to really understand why there are problems with some topics, we should change the way these topics are taught and measure the knowledge again. Only after several repetitions of such tests one would have some solid ground for the changes and only than should the changes of the curriculum be made. We all know that nobody in politics has the patience to wait so long. New changes of the curriculum are often made before the school manages to fully appreciate the last changes. With this respect we do not dare to suggest changes in the curriculum, but we rather give some hints on what the teachers (in Slovenia) should pay attention to while teaching physics.

The paper is organised in three larger units. In the next chapter the assessment is presented in detail in order to understand the measuring tools that are used. In the following chapter a few typical problems are presented. Finally, the implications for the curriculum development are summarised in conclusions.

NATIONAL ASSESSMENT OF PHYSICS

The national assessment exam in physics is set up of 20 written problems, spanning the syllabus of physics (the last 2 years of elementary school, 8^{th} and 9^{th} grade, 2 hours per week) and physical topics in the subject "natural science" (the 7^{th} grade, about 18 hours in the entire year). Depending on the length and complexity 1 to 4 points are assigned to each problem, but the overall sum is fixed to 36 points. There is a point assigned for each step in solving each problem. The average score (Figure 1) was 16.8 points, i.e., 46.6 % of maximum possible number of points for 4,548 pupils in 2007 (Bajc, Beznec, & Verovnik, 2007) and 15.8 points (43.8 % of maximum) for 4993 pupils in 2008 (Bajc, Beznec, Ferlinc, Semen, & Verovnik, 2008). All cognitive levels after Bloom (1956) are present in the test, so this result is not a surprise, as we include only about 20 % of low cognitive levels (knowledge and recognition, level I), about 55 % of intermediate cognitive level (comprehension and application, level II), and about 25 % of high cognition level (analysis and synthesis, level III). The distribution of questions is so much in favour of higher cognitive levels, because physics is all about understanding nature. Thus knowing definitions or recognizing correct units or wording of laws of physics is not enough. What pupils should gain from physics is a scientific approach to nature, the ability to recognise key variables in particular relations and to learn how to combine theory and observations. In addition, they should develop critical thinking. For example, they should learn how to ask relevant questions related to particular phenomena. One of the major advantages of physics in comparison to other nature science subjects is that experiments can be made relatively simple, preferably with just one variable to observe, and can easily be repeated. On top, theoretical models reproduce the experiments well, if the experiments are chosen correctly. All this should be used to encourage the pupil’s curiosity and direct it into development of a natural scientific approach when observing nature.

The distribution of the points over the representative sample of pupils is shown in Figure 1. In order to generalise the results, four groups of pupils with distinctively different overall results have been generated. In the *G1* group (Figure 1, line-hached bars) there are around 10 % of pupils whose result is around the first quartile border, i.e., such pupils that roughly 20 % of all pupils did worse than *G1* group and roughly 70 % of the pupils did better than the pupils in the *G1* group. Similarly, the *G2* group (Figure 1, grey bars) includes pupils around second quartile (45 – 55 %), the *G3* group (Figure 1, doted bars) includes pupils around third quartile (70 – 80 %), and the *G4* group (Fig. 1, black bars) includes pupils with the best results – upper 10 % of the population.

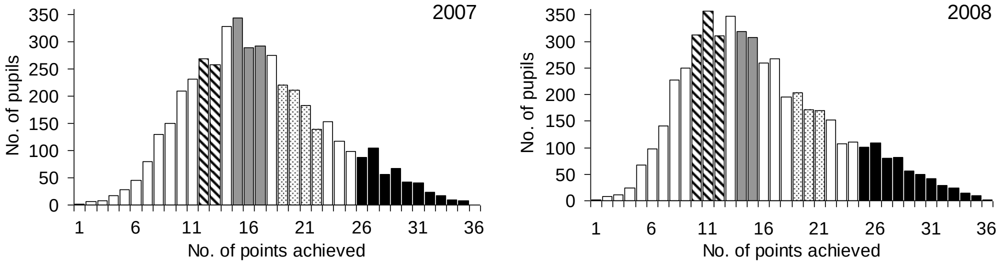


Figure 1: Overall distribution of the assessments in 2007 (left) and 2008 (right).

Each assigned point of the questions is placed in a group according to the success of the pupils at a particular sub-question in each group of pupils. So the problems are also subdivided into groups *G1*, *G2*, *G3*, and *G4* (Table 1). A sub-question is put in a group that is named by the group of pupils with the lowest overall knowledge, who have successfully answered the sub-question. We decided that a sub-question is successfully answered by a particular group of pupils, if more than 2/3 of the group answered correctly. If, for example, a sub-question is answered correctly by 50 % of the G1 pupils, by 70 % of the G2, 80 % of the G3, and 90 % of the G4 pupils, we put it into a group of G2 questions. An additional group of questions is formed by the sub-questions that have statistically not been successfully answered even by the best 10 % of the population. These sub-questions fall into the "*above the G4*" group. General conclusions are drawn from the common characteristics of each group of sub-questions. We illustrate the analysis by a few examples.

Table 1: Distribution of the sub-questions (i.e., points) according to the group of pupils that successfully solved a problem.

Group	Year 2007	Year 2008
G1	6	6
G2	3	2
G3	4	7
G4	17	14
Above G4	6	7

A detailed argumentation of the findings of the 2007 and 2008 assessment is beyond the scope of this paper. We summarise the findings here and advise more interested readers to read the official yearly report on the 2007 and 2008 assessment of knowledge of physics (Bajc et al., 2007, 2008).

EXAMPLES OF THE PROBLEMS

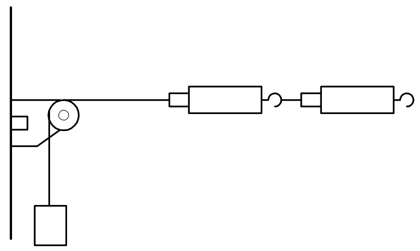
Due to space limitations only a handful of problems are presented with the emphasis on the possible multiple interpretations of the results. These problems are the ones that can be misused by the educational authorities and policy makers. We hope to illustrate that changing curriculum is a delicate matter and should, in our opinion, be made preferably in a slow continuous way rather than dramatic changes. In particular we oppose making successive drastic changes in short – a few years, for example – time intervals.

PROBLEM EXAMPLE 1

This example from the 2007 assessment test is a multiple choice question related to equilibrium of forces and third Newton's law (Figure 2). The original wording of the problem reads:

A one kilogram weight in the figure is at rest. What are the forces shown by each of the two dynamometers?

Encircle the letter in front of the correct answer.



A The first 5 N, the second 5 N.

B The first 5 N, the second 10 N.

C The first 10 N, the second 5 N.

D The first 10 N, the second 10 N.

Figure 2: An example of a multiple choice question related to the first and the third Newton's law, taken from the 2007 assessment test.

The number of pupils choosing particular answer was: A – 2214, B – 659, C – 437, and D – 1123. The correct answer is D: each dynamometer shows a force 10 N.

Although this turned out to be one of the most difficult questions in the entire 2007 test and its content could be a topic for itself, at this point we want to stress a different aspect. This problem is a fine example of the advantages of a multiple choice question.

The number of the pupils that answered correctly is small for all pupil groups (Table 2). We infer that on average the pupils do not understand the third Newton's law or they do not know it or maybe they do not know how to use in this particular situation. We also notice that pupils with better overall score solve the problem better than the pupils that did not do so well the entire test. If in the analysis of the results only the correctness of the answers is taken into account, there is nothing else we can get from this problem. We could only speculate on why the score is as bad as it is.

Table 2: The statistics for the first problem example.

Portion of pupils solving the problem [%]				
G1	G2	G3	G4	Overall
20.3	25.1	27.9	38.3	25

There could be a lot of information in the distribution of the selection of the wrong answers and suitably constructed multiple choice questions provide a possibility to get additional insight into the pupils' reasoning. In this problem, wrong answer "A" was particularly tempting for the pupils, as they selected it two times more frequently than the correct answer "D". Since the answers "B" and "C" are far less frequent, we can conclude with high certainty that the pupils confuse first and third Newton's law or that they do not distinguish between the two.

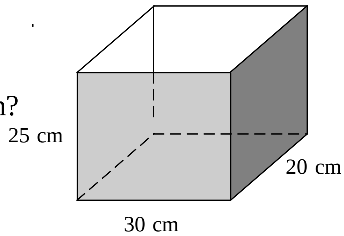
In order to go deeper into pupils reasoning, additional questions related to both Newton's laws should be asked and answered, but in the framework of the national assessment this is not possible due to logistic limitations. National assessment has to span the entire curriculum in a limited time, so details are sacrificed on account of a global picture.

One may be tempted to change the part of curricula that is related to Newton's third law, advocating the topic to be too difficult for the population in the primary school and 'proving' it by the bad overall score of the problem example 1. On the other hand, extended analysis including the distribution of the selection of the incorrect answers indicates that the reason might not be the difficulty of understanding the third Newton's law. It seems that the problem is the distinction between the third and the first Newton's law. So, instead of dropping something out of curriculum, one could advocate to pay a little more attention to the distinction between the two Newton's laws. Since it is not 100 % clear from the national assessment results, which option is better, many different curriculum changes can be justified depending on the interpretation of the results.

PROBLEM EXAMPLE 2

This example from the 2008 assessment test is an open ended question with four sub-questions related to volume, mass, density, weight, and pressure (Figure 3). The original wording of the problem reads:

An aquarium has length 30 cm, width 20 cm, and height 25 cm. It is fully filled with water.



a) How many litres of water are in the aquarium?

Answer: ______________________

b) What is the mass of the water in the aquarium?

Answer: ______________________

c) What is the weight of the water in the aquarium?

Answer: ______________________

d) For how much is the pressure at the bottom of the aquarium larger that the pressure at the water surface?

Answer: ______________________

Figure 3: An example of a multiple open ended question checking relations between volume, mass, weight, and hydrostatic pressure.

This problem was intended to measure the ability of pupils to convert volume to mass, mass to weight, and finally, to calculate the hydrostatic pressure. Density of water is given as a supplement of the assessment test.

Table 3: The statistics for the second problem example.

Portion of pupils solving the problem [%]					
Sub-question	G1	G2	G3	G4	Overall
a)	23.1	49.0	79.4	95.6	50
b)	12.9	32.7	72.3	96.1	42
c)	3.5	17.9	54.3	94.3	31
d)	0.3	2.6	12.7	54.0	11

As one can see from table 3 and figure 4, the pupils with the best overall score (group G4) have no problem calculating the volume and converting volume to mass and weight of water. But even in this group only every second pupil correctly calculated the pressure difference between the surface and the bottom of the aquarium. For the first three groups of pupils, G1, G2, and G3, for each succeeding sub-question the score is substantially smaller than the score for the preceding sub-question (Figure 4). Besides the score itself we would like to know the reasons for these relatively bad results. Because this is an open ended problem, it is extremely time demanding to read and group into classes all given answers to particular sub-question and to make further conjectures about possible lack of knowledge that produced observed results. Neither the analysis centre at the National examination centre nor the Subject committee for physics have the man power to do such detailed analysis, so we are left with speculations.

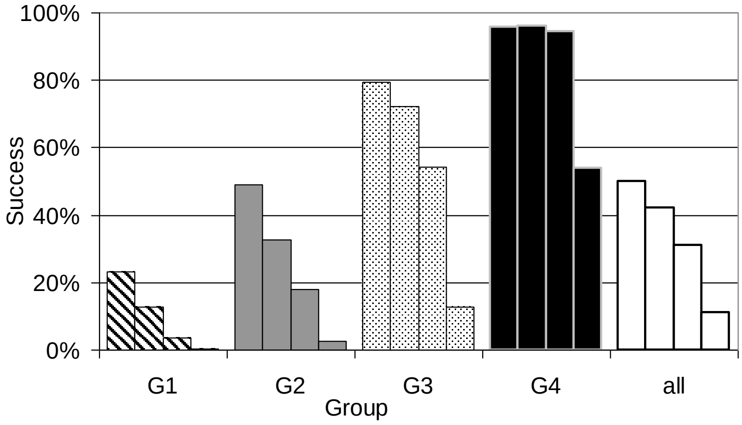


Figure 4: Success of the representative student groups in sub-questions of the second problem example. For each student group the first column represents the success in sub-question a), the second in sub-question b), the third in sub-question c), and the fourth in sub-question d).

The incorrect results to sub-question a) can be, for example, a consequence of not knowing how to calculate the volume of the aquarium or of not knowing how to convert units or of a simple mistake in calculation or not writing the units beside the calculated number, etc.

We definitely can identify that the overall success of this problem is not as good as we expected, but we do not know the most frequent reason for the pupils' failures, so we cannot suggest any curriculum changes, based on the analysis of this question. Nevertheless, we did point out to teachers, that they should find out how their pupils managed this problem. If they find out that their students failed because of the unit conversion, they should pay more attention to unit conversion. Similarly, if the failure was mainly a consequence of not knowing how to calculate the volume of the aquarium, the physics teachers should consult mathematics teacher in order to see how and when the pupils learn about that formula. Further, the teachers should adjust teaching, so that this topic is treated after the time the pupils learn this formula. But all this advises are not directly related to curriculum change.

CONCLUSIONS

The national assessments of knowledge of physics provide valuable data on the state of knowledge of physics among the pupils at the end of their elementary education at age around 15. Coherent results (Figure 1 and Table 1) and similar general findings, such as lack of ability to solve structured problems or good results when answering simple reproductive questions, indicate that the assessment as a measuring tool is working fine. Nonetheless, for various reasons, such as only two measurements in 2007 and 2008 and limited number of problems related to a specific topic, it is not possible to predict the effect of particular curriculum changes on the knowledge gained, let alone acquired competences. As we have shown by a few examples, interpretation of the results allows too much freedom to justify this or that particular change in the curriculum. In other words, national assessment is designed to measure the knowledge and it shall detect the change of knowledge, should there be one, but it is not at all certain, that the analysis of the assessment tests will reveal the connection between the curriculum change and the change of knowledge of physics. Last but not least, in order to reasonably adjust the curriculum, some studies relating the methods of teaching to the knowledge gained by the pupils should be done in addition to the existing assessments of knowledge of pupils.

ACKNOWLEDGEMENTS

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FIRST YEAR UNIVERSITY STUDENTS' CONCEPTIONS ABOUT CELL

Barbara Bajd

University of Ljubljana,

Faculty of Education

barbara.bajd@guest.arnes.si

ABSTRACT

Some teachers have voiced concerns that knowledge and understanding of biology, especially about cell structures and mechanisms, is not sufficient in upper secondary school because there not enough hours in the curriculum are devoted to biology teaching. Some teachers have even advocated that 'the cell' should be taught in primary school. Too detailed teaching about cell structure and mechanism with excessive data can be reflected in poor understanding and a lack of basic knowledge about cells and cell mechanisms. Our investigation showed that students of the first year at the Faculty of Education (after finishing upper secondary school) do not have enough basic knowledge about cell structure and its major inclusions. The reason is not a lack of hours in the curriculum for biology, but rather the approach to teaching basic biological knowledge.

Keywords: *cell, students' conceptions about cell structure, misconceptions*

INTRODUCTION

The 'Cell' is a largely abstract notion for primary school pupils, and so in Slovenia cell structures and mechanisms are not taught until upper secondary school. All pupils who have completed upper secondary school have had at least 15 hours devoted to cell structures and cell mechanisms, and in some schools that time has more than tripled to (47 hours). Students are expected to know about organelles (such as plastid, vacuole, mitochondrion, Golgi apparatus, lysosom, endoplasmatic reticulum, ribosome, cilia and flagella, centrioles, nucleus, cell wall and plasma membrane) as well their functions. So we might expect that students entering the first year at university would have appropriate knowledge about cells and cell mechanisms. We consider that the current teaching allocation in upper secondary school provides sufficient time for pupils to acquire information about cell structure and function, and extending the time allocated within the curriculum will not improve that knowledge. It will be far more effective to change the teaching approach to the topic to produce better understanding by pupils. Some investigations show that within biology intrinsic motivation is higher for learning concrete contents (e.g. the human body, systematics, ecology) rather than more abstract ones (e.g. microorganisms, cells genetics) (Juriševič et al. 2010). A knowledge of cell structure is a necessary prerequisite for effective understanding of cell processes and their functions. The purpose of our study was to assess the conceptions and understanding of cell structure among students in the first year at the Faculty of Education, University of Ljubljana.

METHOD AND RESULTS

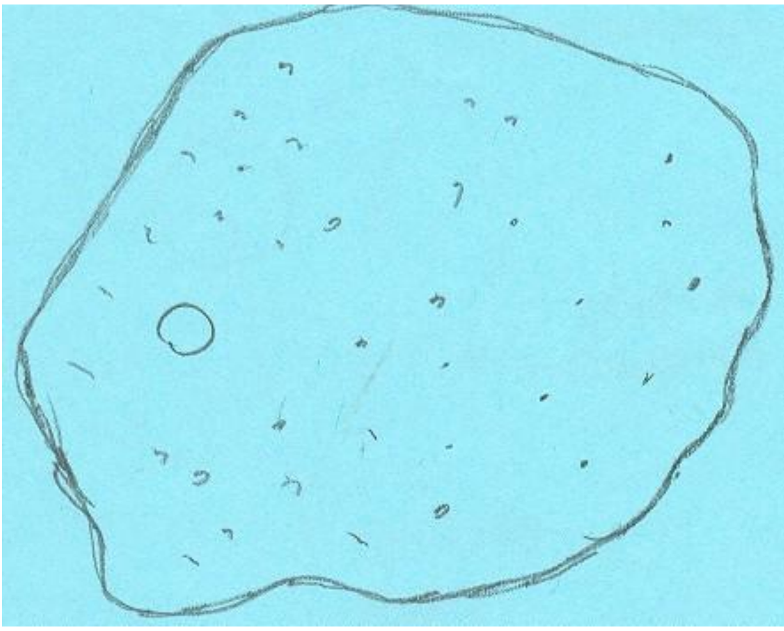
The categories of student included in our survey reflect the structure of education and teacher training within Slovenia: we questioned 96 primary school students (training to teach children aged 6 -10 years) and 47 preschool students (training to teach children aged 0 - 5y years) for this study. We asked them to draw a cell and its internal structures, and to label them, since we wished to know which organelles they still remember from upper secondary school. (At this point they had not had any teaching on cells and cell structures within the Faculty of Education). We planned to use the results as the starting point for a lecture on cells in science lessons at the Faculty. Before they started to draw, students of primary school teachers asked if they have to draw an animal or plant cell, while preschool teacher students did not put this question. We collected students' drawings and analysed them. Three primary school students drew plant *and* animal cell, the rest of the students had drawn *either* a plant *or* animal cell. Plant and animal cells differ in some organelles: plant cell contains a cell wall and chloroplasts, but animal cells lack these so those drawing animal cells could not include these, and we have therefore omitted them from the following analysis and discussion. The results indicating which organelles primary school students (RP) and preschool students (PV) mentioned are presented in table 1.

Table1. Cell organelles and cell structures mentioned by primary school (RP) and preschool (PV) students.

	N	C	P	GA	ER	M	R	Nc	C	L	Cit.
RP	96%	89%	34%	22%	9 %	55%	11%	9%	2%	1%	1%
PV	87%	21%	40%	9 %	2%	19%	4%	-	-	-	-

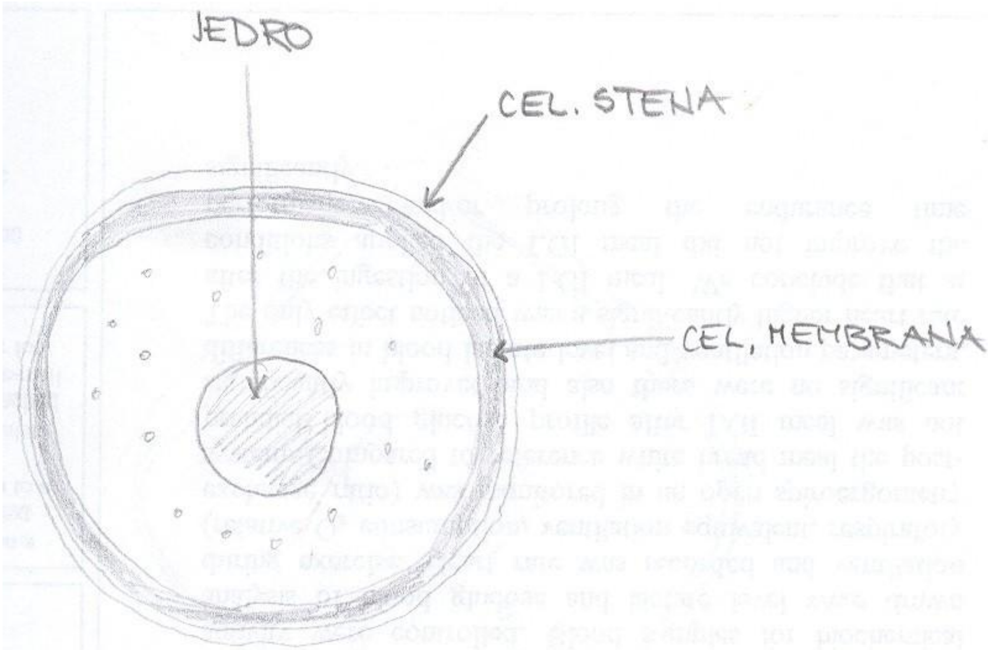
N- Nucleus
C- Cytoplasm
P- Plasma membrane
GA- Golgi apparatus
ER-Endoplasmatic reticulum
M- Mitochondrion
R- Ribosome
Nc- Nucleolus
C- Centriol
L- Lysosom
Cit- Cytoskeleton

We also analysed the students' drawings, which differed a good deal. Some were very simple and lacked explanation (see, for example, picture 1). As we can see from this picture, the preschool teacher who drew it had in mind that there are some structures within the cell, but she did not know their names, including that for the large circle, which probably represents the nucleus.



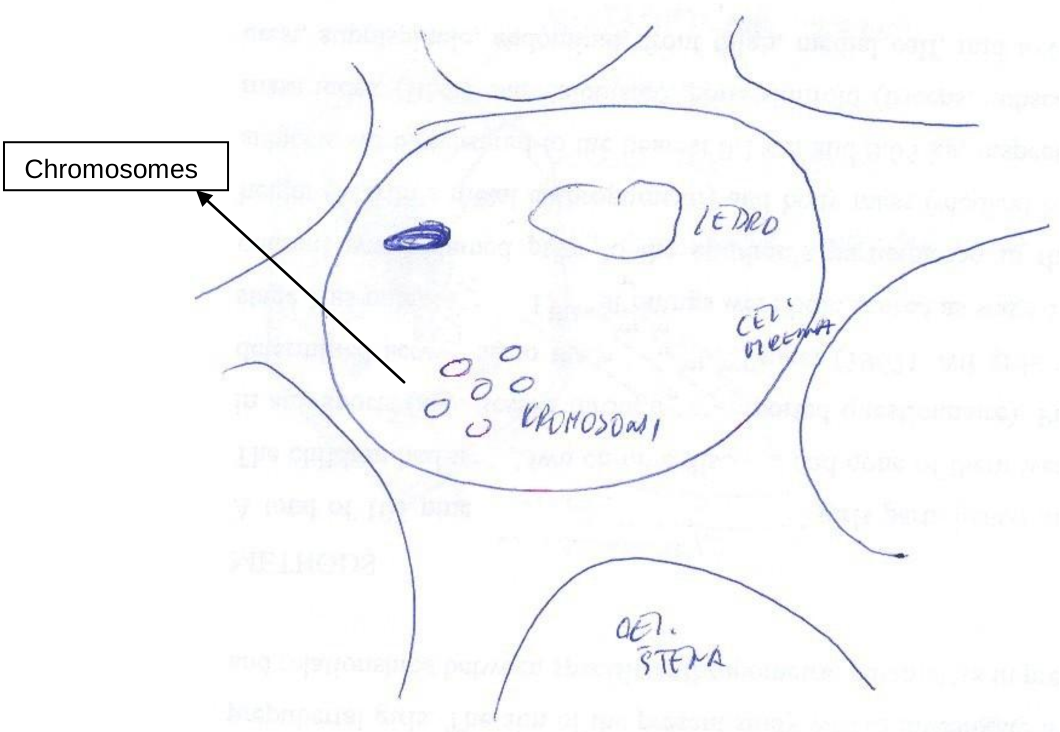
Picture 1: Drawing of the cell without named structures

The majority of students drew the cell as represented in picture 2, with a nucleus and plasma membrane, and in plant cells they also drew the cell wall. Some pre-school students drew the cell and some internal structures, but they could not name them, or named them incorrectly.



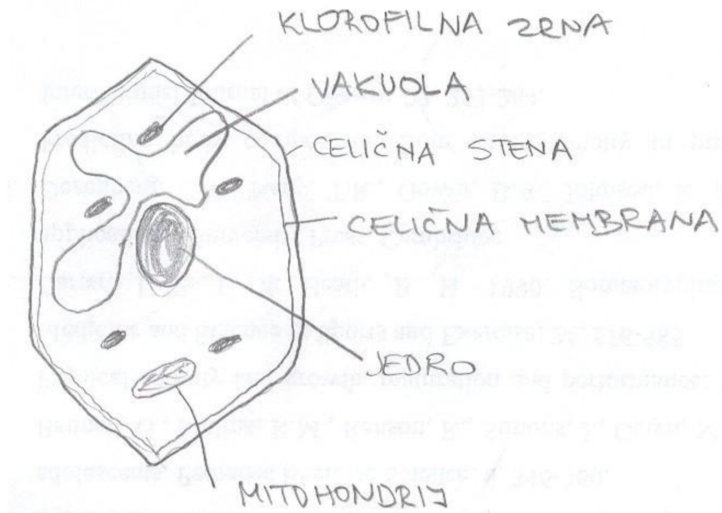
Picture 2: Drawing of the cell and some internal structures. Some are named and some not.

In picture 3 we can see that the student drew the chromosomes in cytoplasm outside the nucleus, indicating that she is unaware that chromosomes or DNA are situated within the nucleus. The black spot probably represents a mitochondrion.



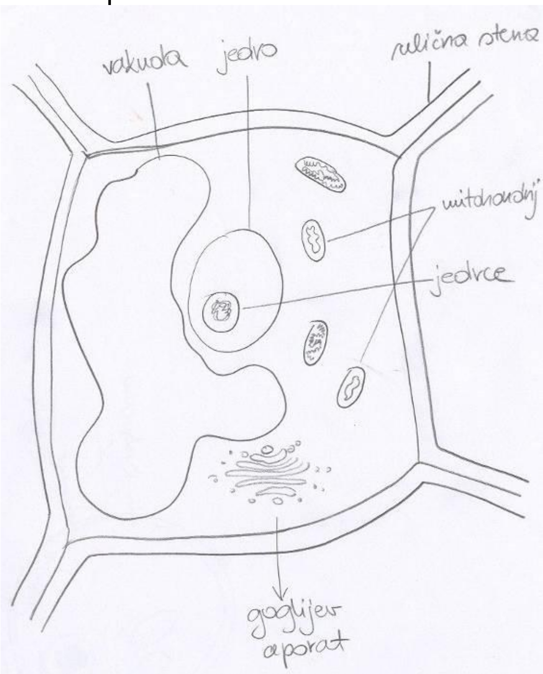
Picture 3: Drawing of the cell where chromosomes are situated out of the nucleus.

Picture 4 presents a good picture of a plant cell, with nucleus, mitochondrion, chloroplasts vacuole, plasma membrane and cell wall, drawn by a pre-school student teacher. Only one of the pre-school teacher students drew and named the endoplasmatic reticulum. We do not know whether the student meant an agranular or granular endoplasmic reticulum, and she has drawn it away from the nucleus, indicating she is unaware that granular endoplasmic reticulum is connected to the nuclear membrane. Very few pre-school teacher students drew the Golgi apparatus (9%) or ribosomes (4%), and none of them drew the nucleolus, centriol, lysosome or cytoskeleton.



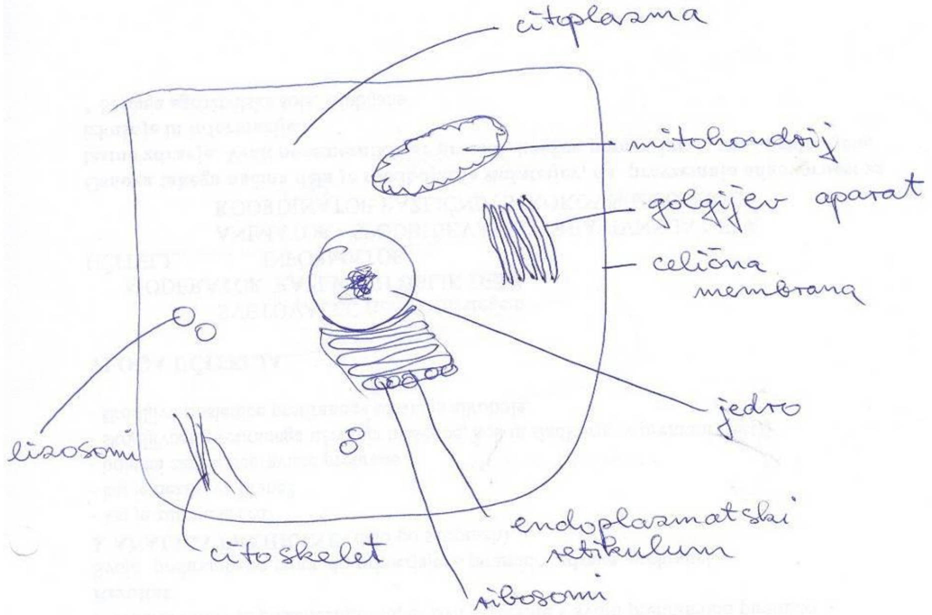
Picture 4: Drawing of a plant cell, with nucleus, mitochondrion, chloroplasts vacuole, plasma membrane and cell wall, drawn by a pre-school teacher student.

The primary school teacher students drew the cell with more details and cell organelles. They also drew the nucleolus (picture 5), which none of pre-school teacher students drew. A greater proportion (55%) of primary school teacher students also included mitochondria in their drawings compared with the pre-school teacher students.



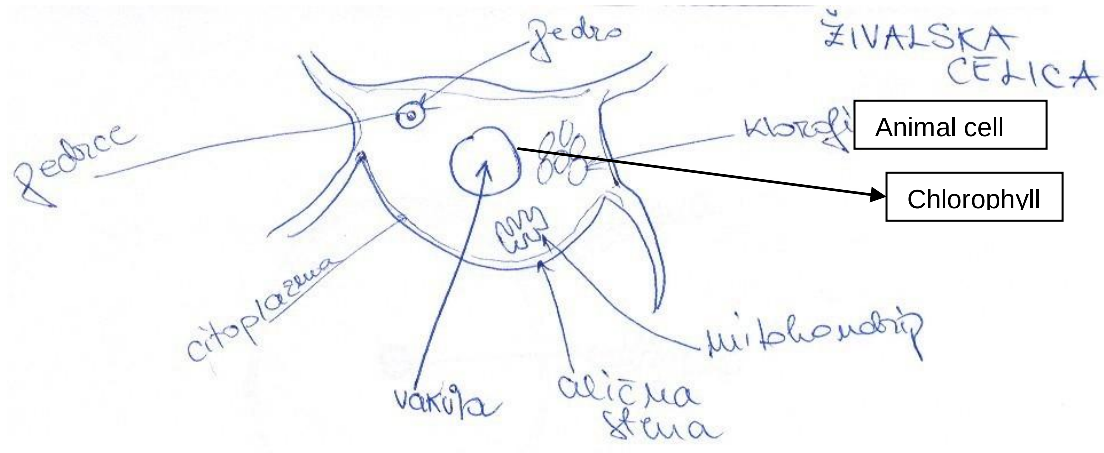
Picture 5: Drawing of the cell with more details and organelles

Greater numbers of primary school teacher students (89%) also marked the cytoplasm in the cell (picture 6) compared with pre-school teacher students, and one also drew lysosomes and the cytoskeleton. Those who draw the endoplasmic reticulum drew it in connection with nuclear membrane, or even drew ribosomes on it. But the majority of those who drew ribosomes placed them within the cytoplasm and not on the endoplasmic reticulum.



Picture 6: Drawing of the cell with lysosome, granular endoplasmatic reticulum and cytoskeleton

Picture 7 represents the animal cell. The student who drew it probably did not know the difference between animal and plant cells since she drew and marked both chlorophyll and a cell vacuole. It is probable that the student did not know the function of chloroplasts, and that they and the contained chlorophyll are the main characteristics of green plant cells.



Picture 7: Drawing of animal cell with chlorophyll

CONCLUSIONS

This investigation was prompted by a growing awareness among Slovenian science teachers that students' understanding of cell biology was more limited and less effective than that of other areas of the science syllabus, leading to a general debate about the nature and extent of teaching these topics within the secondary school curriculum. Some teachers have argued that there is insufficient time allocated to teach the complex concepts involved, so pressing to expand the time available at the expense of other topics. However, an alternative interpretation is that it is not the time available but the design of the lessons and approach to teaching the subject that militates against students' effective understanding.

The results presented here indicate that despite the fact that every students in upper secondary school has been taught about cells, cell structures and organelles, their recalled knowledge is very limited. We asked them only to draw the cell organelles, and not to list the functions and mechanisms of organelles. As noted earlier, an acquaintance with cell structure is a necessary prerequisite for any understanding of metabolic processes. Moreover, since cell structure is concerned with knowledge of specific objects (nucleus, vacuole, mitochondrion etc) for the great majority of school students it is easier to understand than the more diffuse and theoretical concepts of cellular processes and their functions. Had we asked our students questions on cell mechanisms we therefore think that we would probably have been presented with even more limited knowledge. We plan to test this supposition and to investigate aspects of students' understanding of cell processes and functions in further surveys.

We can see from our results that the majority of students knew that the cell has a nucleus, but nobody mentioned or drew a bacterium cell or human red blood cells which are exceptions to this generalisation. Cytoplasm was mentioned much less by the preschool teacher students than by the primary school students, with only one fifth of preschool teacher students and nearly 90 % of primary school students marking the cytoplasm. The results indicate that intending primary school teacher students had much better knowledge of cell structures than pre-school teacher students. For example, mitochondria were mentioned by more than half of the primary school students, while less than a fifth of pre-school teacher students mentioned these structures. If they are unaware of mitochondria they will not understand their function, and so are unlikely to know that plant and animal cells contain organelles that are responsible for cell breathing (Hersley, 2004). This further confirms the findings of another investigation we undertook in our faculty that 14% of students still fail to realise that breathing and photosynthesis are two different (opposite) processes, although they were taught that in their first year of study at the Faculty. The main function of mitochondria is the conversion of energy stored in carbon-containing molecules, especially glucose, into high-energy bonds of ATP, which is the only usable energy source for many cellular activities. This basic fact should be known by every teacher student, whether intending to be a preschool or primary school teacher.

We provisionally conclude that, despite many hours (20-47 hours depending on the particular programme) spent teaching cell structure and function in the upper secondary school curriculum in Slovenia, students do not have enough basic knowledge of cell organelles and structures. We take the view that there is currently enough space within the biology timetable to provide students with the relevant basic knowledge of these topics. Rather, the problem is that students have to learn too many details and do not focus on the basic information required to understand the fundamental mechanisms of the living world. With so many facts and so much information having to be memorised for pupils to achieve a good mark, they loose sight of the main points, and fail to see the wood for the trees. So teachers should be selective in the subject detail they provide, and plan carefully what and how much to teach about cell topics so that pupils thoroughly understand the most fundamental aspects of the structure, mechanisms and functions of cells. We intend to explore further aspects of students' understanding of cell structure, processes and functions in future surveys, and to consider in detail their implications for the design of lesson plans, curriculum materials and learning resources for these topics.

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VISUAL ARTS AND PHYSICS MODELS IN COMPETITION WITHIN AN ICT-BASED ACTIVITY: COLOR AS MATTER OR COLOR AS LIGHT?

Karine Bécu-Robinault

UMR ICAR Université de Lyon - France

Karine.Robinault@inrp.fr

Shirley Takeco Gobara

Universidade Federal de Mato Grosso do Sul - Brazil

gobara@dfi.ufms.br

ABSTRACT

This investigation is a case study based on a teaching situation developed to help 8th-grade students build a physics model for the additive synthesis of colored light. Devised within a research development group, the teaching sequence integrates the use of free downloadable simulation software and the handling of real teaching materials. The data collected consisted of video recordings of a group of students and their teacher, with partial multimodal transcriptions. Excerpts of the transcriptions were analyzed by identifying the points of view held by students and teacher on the comparison of simulation and practical experiments. The evolution of these points of view and their discussion by the participants were examined from a theoretical perspective, allowing the classroom discourse to be analyzed. Concurrently, the bridging of the two competing models derived from separate teaching cultures—i.e. the visual arts and physics—was discussed from a modeling perspective. Common sense knowledge or visual arts terms used by the students were found to interfere with physics-specific knowledge and terminology, revealing underlying concept misunderstandings and factual misconceptions.

Keywords: *optics, models, color.*

INTRODUCTION

This investigation is rooted in the many years of experience of our research teams—which are investigative groups founded on a collaborative effort of practicing teachers and researchers—in designing physics and chemistry teaching sequences for use in upper secondary schools. One of our central hypotheses is that modeling activities carried out by students are, from an epistemological point of view, related to the mode of construction of physics concepts (Bécu-Robinault, 2002).

In addition, other theoretical underpinning aspects were taken into account, addressing the role of social interactions in learning and the role of misconceptions in the process of learning and teaching described in science education research. In this perspective, a range of teaching-learning sequences have been developed, implemented in classrooms, and evaluated. Our first learning objective addressed the discussion of a model capable of allowing students to interpret colors obtained by superposing several colored lights. The second objective was to make the modeling process underlying a software-based simulation explicit. This paper focuses on the interaction between 8th-grade students and their teacher during an activity involving additive color synthesis aided by simulation software (Visiolab[3]) and practical experiments.

[3] The software can be downloaded from ftp://ftp.discip.crdp.ac-caen.fr/discip/phch/college/quatrieme/visiolab.zip

THEORETICAL FRAMEWORK

We selected a theoretical framework capable of encompassing social interactions occurring in the science classroom. Viewed in this light, learning is the result of a negotiation of new meanings. The classroom context can be characterized by the status of its actors: the teacher presents a clear-cut point of view (that of school science discourse), whereas the students have their own points of view, albeit not always well thought out and differing from one student to another—and even more often from the teacher's view. Generally, the teacher's point of view is assumed to be accepted by all students by the end of the lesson. In order to enable the students to discuss the validity of pieces of cultural knowledge originating from different cultural backgrounds, the teacher has to negotiate the introduction of this range of points of view during the class. The manner in which the teacher organizes the confrontation of differing points of view is an important element in the analysis of speech in the classroom. To this end, Mortimer and Scott (2003) addressed the communicative approach by considering communication in its various dimensions. They concluded that communication can be described as "dialogical" if the teacher takes into account the variety of points of view stated by the students; conversely, it is described as "authoritative" if the teacher takes into account only the point of view of the school knowledge. The "dialogical" versus "authoritative" dimension is independent of the number of individuals in interaction. Mortimer and Scott also proposed a second dimension: "interactive" or "non-interactive." A given approach is described as interactive if more than one person takes part in the discourse, and as non-interactive when discourse is limited to one student. These investigators claim that alternation between authoritative and dialogical approaches facilitates the learning process.

Scientific discourse is characterized by specificities. Kress et al. (2001) demonstrated that learning to talk about sciences at school goes beyond verbal aspects. The scientific discourse is multimodal and uses multiple semiotic registers (Duval, 1995). Learning science implies the appropriation of concepts, instruments, and cultural practices by a multimodal language (Lemke, 1990). Interactions in science classes are therefore organized with a plurality of multimodal resources, including gestures, glances, body postures, movements, and questions and answers from students and teachers alike, and also involve the handling of objects, texts, charts, sketches, diagrams, and lists of number, in addition to the use of simulations and other procedures.

MODELING ACTIVITIES

The effect of the information conveyed by the written instructions accompanying a simulation device and furnished orally by the teacher during the modeling carried out by students also has to be examined (Bécu-Robinault, 2002). While performing modeling activities, students establish relationships between two levels: the level of theories and models and that of objects and events. For instance, while describing an experimental situation such as a lamp that shines, students will be addressing the level of objects and events. On the other hand, while interpreting or predicting what occurs in terms of current or energy, they will be dealing with the level of models and theories. Learning physics implies learning how to integrate both levels (Tiberghien, 1994).

In the situation investigated in this paper, two color models from distinct cultural and teaching domains can be mobilized in the discourses of students and teacher. The model that the teacher aims to introduce is the physics model of additive color synthesis, which considers color as light. The second model, usually taught in visual arts courses—and also found in everyday life—is grounded in subtractive color synthesis and requires color to be viewed as matter, not light. An analysis of the current French official visual arts curriculum reveals that the subtractive synthesis model has previously been taught to 8th-grade students, allowing them to interpret or predict phenomena on the basis of either the color-as-light model or the color-as-matter model, in association with terms that refer to one of these models or even terms referring to both models. In fact, some of these terms, such as color names, can be ambiguous. When a determiner precedes a color name, the name tends to be implicitly interpreted as relating to the color-as-matter model. When preceded by the determiner "light," the color-as-light model is evoked. The term "mixing" tends to evoke the color-as-matter model, rather than its color-as-light counterpart. A more appropriate term for light syntheses would be "superposition."

With these elements in mind, our purpose was to analyze the discourses taking place in the classroom in terms of modeling levels and competing reference domains.

RESEARCH QUESTION

In the context of this theoretical background, the purpose of the present investigation was to investigate the role played by a teaching sequence and the interactions attendant on the verbal, written, and simulation activities proposed to interpret phenomena related to the superposition of colored lights and to facilitate the construction of an underlying physics model by middle school students.

METHOD

CHARACTERIZING THE INVESTIGATION: DATA COLLECTION AND CORPUS ANALYSIS

A qualitative methodology suitable for case studies was selected for this investigation. Video recordings and partial multimodal transcriptions of the discussions held by three students (herein given the fictitious names Chuck, Nick, and Julia) were made before and after using the Visiolab simulation software. The teacher's discourse was also recorded. Handouts distributed by the teacher and completed by the students were collected for analysis. Physics and visual arts curricula were used as references to analyze cultural knowledge.

ANALYSIS OF THE TEACHING SITUATION: THE TEACHING STRATEGY

In a preliminary activity, students produced colored lights using color filters and a conventional light bulb (data not shown). Subsequently, and with the purpose of collecting data for the present analysis, the students were asked to predict the light color obtained by mixing two (or three) of the following colored lights: blue, red, and green. Subsequently, they were asked to compare their predictions with the results of the software-based simulation. Finally, the teacher asked them to reproduce the simulated experiment using devices generally available in the physics classroom.

Before attending this physics course, the students were familiar with the color model taught in visual arts classes—i.e. the subtractive color synthesis model. In this physics class, they were supposed to use the physics model of additive color synthesis.

A PRIORI ANALYSIS OF THE SITUATION

THE WRITTEN INSTRUCTIONS

The students were given a table to complete with answers on the predictions made before using Visiolab and with the results achieved in the simulation. They were initially asked to name the colored lights obtained by superposition and to fill in each corresponding box with color pencils. These instructions introduce ambiguity with regard to the model they are to use. On the one hand, they have to think about superposing colored lights; on the other, they are asked to represent these lights by coloring a box with pencils to indicate the color of light obtained. These two types of activity may legitimize the mobilization of two cultural models—one from physics, one from the visual arts—by the students.

In France, the official visual arts curriculum states that the subject "colors" should be taught in the 7th grade: "paints are color and matter. […] the color is substance and light, material and immaterial. This is perceived immediately by the observer. […] The student will discover the color spectrum and some of the color organization systems created by painters. While the students learn how to select and blend colors, they should be allowed to experience the sensory, representative, symbolic system and its expressive potentials" (B.O., 2008).

ONE CONCEPTION HELD BY STUDENTS: THE NATURE OF COLORED LIGHT

In everyday language, when someone says "the book is red," color is considered as an innate property of the object. This interpretation comes from intuitive knowledge, yet is incompatible with scientific conceptions (Anderson, 1986). Many studies show that students explain color believing it to be a property of objects (Anderson, 1986; Drive, 1989; Bravo, 2005). Students' explanations are generally built as simple causal relations based on common sense observation. Other conceptions, reported by Feher and Meyer (1992, in Bravo, 2005, p. 341), include colored light viewed as dark and containing color that can be mixed with that of the object. Driver et al. (1989) found that students aged 10 to 15 years usually do not spontaneously relate color to light.

ANOTHER CONCEPTION HELD BY STUDENTS: FILTERS AS COLOR AND LIGHT SOURCES

Investigating students aged 12 to 15 years on their conceptions about the role of filters, Anderson and Kärrqvist (1983, in Bravo, 2005, p. 340) found them to believe that light changes when interacting with a filter, becoming colored by getting color from it. In some situations filters are treated as sources of light and not as materials in which absorption and selective transmission of light take place (Chauvet, 1996).

THE SOFTWARE

When Visiolab is started, three colored circles (red, blue, and green) are superposed on a black background (Figure 1, left). Three colored projectors are depicted at the bottom of the screen. The students can move the lights by dragging the circles, and the orientation of the projectors will change accordingly (Figure 1, right). Although the simulation should address only the physics model, the screen shows circular areas of solid color, but not beams of colored light.

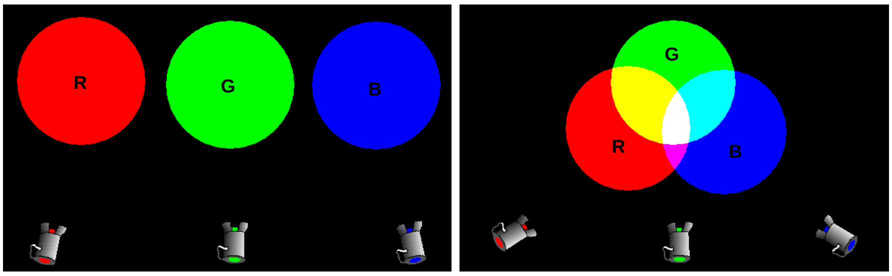

Figure 1: Screen captures using Visiolab software (G: green light; B: blue light; R: red light). White light is visible at the intersection of the three circles.

Operation of this software leads the user to concentrate on the colored circles, not on light emitted by the projectors, and therefore tends to legitimize the mobilization of the visual arts model, even though the results are in accordance with the additive synthesis model.

DESCRIBING AND ANALYZING THE TEACHING SEQUENCE

The tools applied here to analyze interactions and meaning-making in science classes are mostly based on Mortimer and Scott (2002), who proposed an analytical tool consisting of five aspects: "communicative approach," "teaching purposes," "content," "teacher interventions," and "patterns of interaction." The focus is on the teacher's work to introduce and discuss scientific ideas or knowledge regarding the variety of points of view put forward by the students.

Another important aspect to be analyzed is the process of knowledge construction. From an epistemological point of view, science describes phenomena using theories and models. These theories and models allow events to be explained and predicted. From an educational point of view, students are accustomed to the world of objects and events. Representing this world by a model implies an interpretation that students have to apprehend. Generally, teachers do not dedicate much attention to making the difference between the world of objects and events, and the world of models and theories explicit (Buty & Mortimer, 2008). To analyze how the color model of physics is discussed in the science classroom, we also used another analytical tool, based on the categories introduced by Silva and Mortimer (2007a). We chose categories from both analytical tools, according to our research interests. In doing so, an analysis grid emerged (Table 1).

RESULTS AND ANALYSIS

The following sections describe and analyze three of the six episodes in this lesson. Each episode corresponds to a segmentation resulting from the tasks proposed in the labwork sheet or defined by the organization of classroom work by the teacher.

Table 1. Analysis grid and definition of the analyzed aspects

Analysis criteria	Definition of aspects
1 Teaching purpose	Teachers' actions to develop ideas and knowledge in the classroom
2. Communicative approach	▪ Interactive or non-interactive ▪ Dialogical or authoritative
3. Teacher's interventions	Form of intervention to develop teaching content
4. Students' actions	▪ Epistemic actions performed by students (description, explanation, classification, …) ▪ Types of reference (concrete, abstract) ▪ Modeling activities (objects/events, theories/models)
5. Patterns of interaction	Types of alternation in the discourse between teacher and students

In the first episode, the teacher explains the tasks to be performed by the students and rephrases the written instructions. The task involves switching on several colored lights to produce colored environments. The second episode corresponds to the prediction phase (Table 2). In the third episode, the students use the software to collect information on the results obtained from superposing colored lights. Even when the software fails to yield results compatible with the predictions, the students do not express any surprise. The rare discussions taking place among students during this phase address the terminology of the colors visualized in the simulation, but not terms referring to the colors of light. The students designated colors using everyday terms (pink, celestial blue) and did not refer to the color names previously taught in visual arts classes (magenta, cyan). The fourth episode involves discussion of the results achieved using Visiolab in comparison with predictions (Table 2). In the fifth episode the students discuss the possibility of carrying out real experiments. At this point the teacher engages in a negotiation of the concepts to be used: colored lights and not colors: color superposition and not color blending. He manages to ask each group some questions, repeating most of the answers he received. This repetition by the teacher can be interpreted by students as a validation of their answers. The analysis shows that students still do not differentiate between color-as-matter and color-as-light models. The sixth episode evolved from the teacher's wish to engage the classroom in a debate on the experiments proposed by the students (Table 2).

Table 2. Summary of the analyzed episodes

Analysis criteria	Selected episodes		
	2. Prediction task	**4. Discussion of simulation results**	**6. Comparison with practical experiments**
Teaching purpose	▪ Formulate and write down predictions on the colored light obtained when two or three colored lights are superposed	▪ Compare students' predictions and results of a virtual experiment (Visiolab) ▪ Propose an experiment using the materials and knowledge gained in previous lessons	▪ Allow students' conceptions about colored light to emerge ▪ Carry out an experiment with colored lights ▪ Compare observed phenomena with results achieved in the simulation
Communica-tive approach	▪ Non-interactive/dialogical	▪ Interactive/dialogical ▪ Interactive/authoritative	▪ Interactive/dialogical
Teacher's interventions	▪ Teacher does not intervene, but observes the students while allowing them to discuss in small groups	▪ Teacher asks students to compare their predictions with virtual experiments, encouraging them to find arguments to justify the validity of their predictions ▪ Teacher asks students to talk about the possibility of obtaining the same result with materials usually available in the classroom. He proposes they draw a diagram.	▪ Teacher asks students to compare their predictions with the simulation results and to find arguments to explain the validity of their predictions
Students' actions	▪ Epistemic actions by students: explanation and prediction ▪ Types of reference: concrete and abstract ▪ Modeling activities: objects/events	▪ Epistemic actions by students: explanation and prediction ▪ Types of reference: concrete and abstract ▪ Modeling activities: objects/events	▪ Epistemic actions by students: explanation and prediction ▪ Types of reference: concrete and abstract ▪ Modeling activities: objects/events
Patterns of interaction	▪ Discussion among students	▪ Discussion between students and teacher	▪ Discussion between students and teacher ▪ Students present their ideas to the whole class

EPISODE 2: PREDICTION ACTIVITY

In this activity, the students are supposed to formulate and write down predictions concerning the colors obtained, based on previous knowledge. While putting forward their predictions, the students are not actually convinced of their validity. One student, Chuck, makes a prediction based on the color-as-light model: "red and green, that's yellow." Faced with his partners' doubts, he is unable to find any argument to support his view. The following excerpt exemplifies the interaction held between the students while predicting the colored light to be obtained by mixing red and green lights:

Nick: Let's write green. Go ahead!
Chuck: But it won't be green if it's red and green.
Nick: Yes, it will.
Chuck: It will be yellow […].
Julia: Red and green, doesn't that make brown?
Nick: Oh, yes!

The excerpt shows that students shift from the visual arts model (Nick thinks that green and red can produce a type of green) to the physics model when Chuck proposes that the answer is yellow. A few seconds later, Julia reintroduces the visual arts model while posing a question, and proposes “brown.” Because this answer is culturally well-established, Nick and Chuck promptly agree. The group carries on predicting the next resulting colors, using the color-as-matter model. Nevertheless, their agreement seems quite fragile, as if they were not fully convinced; in fact, every answer is either preceded or followed by unenthusiastic phrases such as “Okay, let’s write red.”

EPISODE 4: DISCUSSION OF SIMULATION RESULTS

As the students superpose colored circles on the Visiolab screen, they note down the resulting colored lights on a labwork sheet without questioning these results. The fact that superposing green, blue, and red light yields white light does not seem to draw their attention or surprise them in any way. More strikingly, they do not compare this result with the fact that blending colored pencils does not yield white. The only aspect the students observe using the simulation software is the influence of the order of superposition. During this discussion, one student evokes a previous lesson and introduces a filter to produce colored light. Nick is the first to express his point of view, being promptly supported by Chuck. Nick proposes using a white filter, i.e. a filter thought to be equivalent to the combination of blue, red, and green filters. This argument is based on the software simulation, in which the combination of red, green, and blue light yields white. The group seems to reach an agreement on this first point of view, and they all proceed to write down this answer. Just as they start writing this down, the teacher approaches. A very rich discussion follows, providing an overview of the difficulties of teaching and making sense of the superposition of colored lights. The discourse analysis reveals that common sense knowledge interferes with physics-specific knowledge, as shown by the frequent undue use of visual arts terms in place of physics terminology, revealing underlying concept misunderstandings and factual misconceptions.

As soon as the students seem to have reached consensus, the teacher asks them, “Do you agree?” and begins to move away from the group. The increase in physical distance between teacher and students, reinforced by mimics (a finger on his mouth, Figure 2), is perceived by the students as a sign that the first point of view expressed may not be correct. The teacher’s stance is paralleled by the distance between the students’ point of view and his own. By keeping the students at a distance, the teacher shows that he does not support their point of view.

Figure 2. The teacher stands back from the group (and from their point of view)

The teacher then glances at the three students to make sure they are actually in agreement. He focuses on Julia, who obviously holds another point of view (she shakes her head). The teacher then helps her to express her idea, pointing at her, and coming closer (Figure 3):

Teacher: You’re not convinced.
Julia: No, this is going to produce color.

This change in the teacher’s stance indicates that he is open to new ideas and that the new point of view might be closer to his own.

Figure 3. The teacher points to Julia and draws closer to her (and her point of view)

The students start a new discussion and try to find arguments supporting the new point of view. The teacher observes the group until the discussion comes to a close. Chuck proposes using three colored lights (not three colored filters). The teacher moves closer to Chuck and fixes his gaze on him, thus showing that what is being formulated is crucial. Before Chuck is able to explain how it would be possible to arrange the three lights, the teacher mimics the different spatial positions of these lights and the way the beams meet each other (Figure 4).

The teacher then concludes with "Are you all agreed now?" and moves ahead to another group. This stance is interpreted by the students as an indication that the correct answer is under construction. A final argument is found by Chuck to validate this point of view in relation to the simulation software.

Figure 4. The teacher mimics the way the beams of colored light will meet (shown from left to right: green, blue, and red)

At this point, Nick agrees to change his mind:

Chuck: There are three projectors on the computer.
Nick: Yeah, three different filters with three different projectors.

From a modeling perspective, the analysis of the students' discourse shows that as they proceed in the production of their answer, they keep treating the colored lights they are superposing and the resulting colors obtained as if they were paints.

Nick: Earlier we saw the three make white.
Chuck: We should project a green color, a blue one, and a red one.

The terms "light" and "colored light" are rarely present in their discourses. This absence prevents the activation of the physics model and strengthens the mobilization of the visual arts model. At the end of this episode, we noted, to our great surprise, that the final answer the students chose to note down (Figure 5) did not take into account the previous discussion. Instead, they stuck to their initial point of view—i.e. regarding the white filter as equivalent to a combination of green, red, and blue filters. Moreover, the white filter they proposed is represented with white paint. This answer shows that a strong ambiguity still remains between the two models.

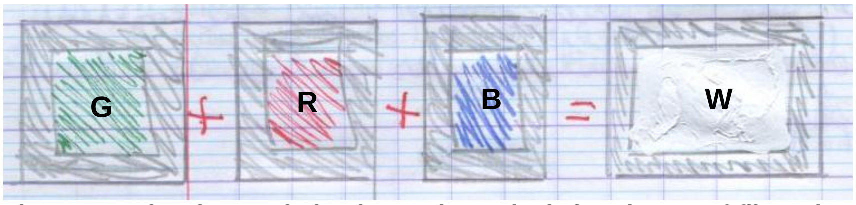

Figure 5. A drawing made by the students depicting the set of filters (G: green; R: red; B: blue) used to produce white (W) light.

EPISODE 6: PROPOSED COMPARISONS WITH PRACTICAL EXPERIMENTS

The teacher begins this episode by recapitulating on the proposals put forward by the groups on how to reproduce the simulation using real materials.

Two types of answer are given to reproduce the simulation using materials generally available in the classroom (Figure 6). The first proposal requires the combined use of three filters; the second makes use of three white light sources, each equipped with a colored filter.

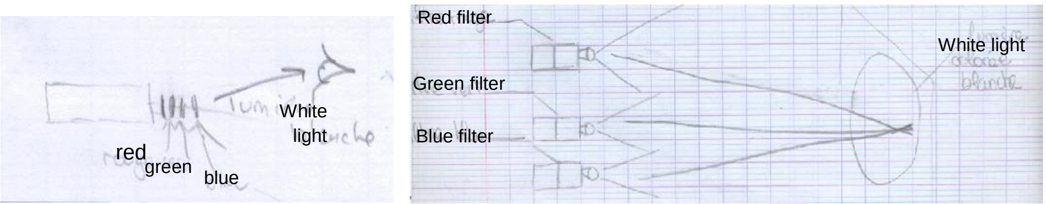

Figure 6. Drawing made by students to depict a simulation based on available materials. On the left, three color filters are associated, producing visible white light; on the right, three colored beams produce white light.

The teacher engages the classroom in a debate on the experiment that might adequately reproduce what has been achieved in the simulation. After debating the availability of material, a discussion starts on what might be observed upon superposing the three filters. At this stage, a student deploys sequential causal reasoning: as light goes through successive filters, it is gradually transformed, so that white light going through a red filter becomes red light, then while going through a green filter it becomes green, and so forth. The point concerning the final transformation into white light is left open. This sequential reasoning seems to be coupled with another understanding of filters: that colored filters might behave like filters used in chemistry classes to change muddy water into clear liquid.

During this episode, students still feel uncomfortable with the presence of two competing models. These difficulties are reinforced not only by the representation of colored lights that students are required to make in their notebooks, but also by the teacher's representation of these lights on the whiteboard. In fact, to represent colored light one must make use of paints or color pencils. Utilization of these tools legitimizes the fact that both the students and the teacher make use of the color-as-matter model.

> Teacher: We're going to draw three small circles: a blue circle, a red circle, and a green circle. In fact that's red-, green-, and blue-colored lights.

In the classroom discourse that follows, the two models are mixed. Both the teacher and the students, through their use of verbal shortcuts and common sense terms, spontaneously mobilize concepts favoring the color-as-matter model. The teacher speaks about "adding lights" (in reference to the additive synthesis) instead of superposing lights. In everyday language, this addition corresponds to the blending of colors as matter.

In the following excerpt, all terms referring to color-as-matter are underlined, references to color-as-light are boldfaced, and color names or other terms that are ambiguous with regard to the model are in italics. Translation required that color names be specified between square brackets as nouns (color-as-matter) or adjectives (ambiguous):

Teacher: We've said that when *adding* **blue-colored light** and **green-colored light** when we *add* **blue-colored light** and **green-colored light** we obtain <u>a blue</u> [noun] that is called *the blue* [adj.].
Nick: *Cyan.*
Teacher: *Cyan.* So we write there cyan […] when we *add* **red-colored light** and **green-colored light** we obtain…
Student: <u>Yellow</u> [noun].
Teacher: **Yellow-colored light** / so <u>yellow</u> [noun], I do not have a <u>yellow pen</u> / so I'm going to write *yellow* / when we **superpose red-colored light** and **blue-colored light** we obtain *a color* that has a particular name...
Nick: *Magenta, magenta.*
Teacher: <u>Magenta</u>. We're going to write M and when **we superpose blue-colored light** and **red-colored light,** and **green-colored light**, **the three colored lights** together, it produces…
Student: <u>White</u> [noun].
Teacher: It produces **white-colored light** / is it the same thing with <u>paints</u>?

At the end of this excerpt, the teacher draws a parallel between what is obtained by blending paints and what is obtained by superimposing colored lights. In French, the words used are the same (mixing). This terminology is confusing and does not help to choose the appropriate model. This episode ends when the teacher states that "paint is matter" and that it is possible to touch paint but not light.

CONCLUSION

The integration of two competing models—the physics model (additive synthesis) and model of visual arts (subtractive synthesis)—is not simple to manage in the classroom. In the situation analyzed here, both models were implicitly invoked. Ambiguity in the legitimacy of each model was unfortunately introduced in the labwork sheet instruction and in the simulation task. Through the dialogical and interactive dimensions of the communicative approach, the teacher attempted to negotiate the exclusive use of the physics model, but his recourse to linguistic forms (metonymies) created misunderstandings and reinforced misconceptions regarding which model should be used in each situation. The ambiguity of these models is not easy to eliminate: students bring their theories about the world, which are based on their own direct experience, everyday language, and scientific theories that have not been fully assimilated, as demonstrated during the interactions that took place in episode 2. In episode 4, this ambiguity remains unresolved because the labwork activity proposes two forms of semiotic representation (naming and coloring in the notebook) that induced the students to consider both situations (mixing lights and coloring on a page) as similar. This led some students to propose a white filter to obtain white light. Finally, the discourse analysis showed that common sense knowledge interferes with physics-specific knowledge, as shown by the frequent undue use of visual arts terms (blending of colors) in place of physics terminology (names of colors), revealing underlying concept misunderstandings (the role of filters) and factual misconceptions (additive and subtractive synthesis). The strategy chosen by the research-development project to elicit predictions based on prior knowledge, compare two types of results, and conclude with practical experimentation was fruitful, but did not succeed in clarifying the two competing cultural models of colored light for the students.

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CAN NEW APPROACHES IN SCIENCE AND TECHNOLOGY EDUCATION ACT AS A MODEL FOR RATIONALIZING SOCIO-CULTURAL AND HUMAN VALUES IN OTHER SUBJECTS?

Mohammed Reza Behrangi

University of Tarbiat Moallem,Tehran-Iran

Behrangimr@yahoo.com

ABSTRACT

A new approach to teaching and learning has been conducted in teaching 54 chapters of four academic texts in four graduate courses within a four year longitudinal semi-experimental case study (216 cases) in educational administration emphasizing students' participation in teaching, promoting cognitive, personal, social, and behavioral skills and changes in their socio-cultural and human values. The approach maps the existing curriculum in each of 54 chapters, generating new map using tenets of curriculum planning in structuring critical concepts, plans for its feasibility in teaching titles and subtitles, plans for using teaching models and technology that fit the instruction, implements the lesson designed accordingly and, evaluates the instructional and nurturing effects on students' socio-cultural and human values of each chapter. A researcher developed questionnaire of 250 items was tested for reliability and validity and reduced to 72 indicators to measure instructional effects. Another developed questionnaire with 100 items designed to measure the changes and interpret students' attitude in socio-cultural and human values. The effect size tools measured the significant effects of the approach. The interrelated 7 models of information processing teaching and 10 chapters of "Supervision", and curriculum map- making are demonstrated here as examples for purpose of transparency.

Keywords*: Rationalizing values, instructional effects, nurturing effects, curriculum map.*

INTRODUCTION

Thinking inductively is inborn and lawful. This is revolutionary work, because schools have decided to teach in a lawless unnatural fashion, subverting inborn and innate capacity (Joyce, Weil & Calhoun 2009 p.83 quoting from Hilda Taba). This introductory statement outlines the message of this article, indicating a new approach is needed as an alternative to protect learners from the destruction of their innate and natural capabilities and aptitudes. The trend to rationalize existing educational administration gives power, restraint and inertia to education to remain at rest, although it sacrifices and endangers students' understanding and concepts attainment. This article provides direction for changing path of traditional education to a sustainable education that has instructional and nurturing effects to the utmost.

THE REVIEW OF LITERATURE AND EXPERIENCES

The emerging approach has a legacy of teaching and learning behind. This legacy has been studied and many years of the author's teaching experiences were used to clarify how to manage teaching to enable students to grasp real science and technology concepts. The main purpose of the approach was to bring ideal and desired instructional and nurturing effects of teaching and learning. Many well-developed models of teaching supported with many lines of researches on their effective size were used. Each of the models makes instructional and nurturing effects on students secured if used. From the 72 questionnaire indicators prepared for gathering data referring to instructional effects one could come up with the conclusion that how the diversity of teaching in different classes, in different cultures and countries has different effects on students and how far today education is from the collective and globalize world ideas on successful and satisfactory teaching. A professional and successful teaching should lead the students to be able to: understanding science concepts, constructing integrative knowledge, finding facts and framework for analyzing social problems and issues, creating scientific definition for phenomena, providing theories from inquiring facts, solving problems through inquiry, making hypotheses on facts, making meaningful assimilation of information and ideas, construct mining of scientific concepts, to be empowered to use tools for metaphoric thinking of science objects, being in the seine to catch new discoveries, gaining the sense of intellectual power, equipped with the intellectual tools for mastering information and concepts, endeavor to reach at the level of mastering of facts and ideas, enhancing strategies for creative inquiry, getting involved in scientific process, using concept learning strategies, understanding the nature of science concepts, making use of concept-learning strategies, applying conceptual systems, forming hypotheses, being involved with concept formation processes. These are some of the indicators of a professional instruction effects on students learning.

On the other hand the nurturing effects (beside the instructional effects) of a professional teaching on students could be seen through administering another questionnaire with 100 indicators as a guide line for students to be empowered with: reflective thinking, self-understanding, integrative communication, ability to assume role of the "others", effective cooperative spirit and skill in group process, empathy, pluralism, awareness of the nature of knowledge, spirit of inquiry, tolerance of ambiguity, conceptual flexibility, comprehensive, penetration, collaborative skills, open-mindedness, ability to balance alternatives, spirit of creativity, autonomy in learning, understanding tentative nature of knowledge, self-esteem, self-understanding, self-reliance independence, and habits of precise thinking.

These two researcher developed questionnaires were provided through cross-cultural comparative and in-depth studying, analyzing the literature and history on researches done on teaching and learning, analyzing too many scenarios of teaching in different levels and grades in different cultures and countries to demonstrate instructing and nurturing indicators of ideal teaching. Each of these instructional and nurturing effects indicators has been based on much research to prove their usefulness.

For the cause of transpiercing of the findings of the literature the studies were referred to in a four components used by Bruce, et al (2009). They classified the models of teaching into social, information processing, personal and behavioral family of models. For the purpose of this study and to demonstrate the instructional and nurturing effects of teaching on socio-cultural and human values of students at all levels of schooling, the 7 models of teaching in the family of information processing models of teaching were dissected and categorized into one group based on the instructional effects on students' learning. These 7 models are:

1- Learning to think inductively- forming concepts by collecting and organizing information,
2- Attaining concepts- sharpening basic thinking skills;
3- The picture-word inductive model- developing literacy across the curriculum;
4- Scientific inquiry and inquiry training- the art of making inferences;
5-Memorization – getting the facts straight;
6-Synectics- the arts of enhancing creative thought;
7-Learning from presentations- advance organizers. Therefore, using these models of teaching is to lead teaching to have instructional effects on students' performance and race to catch the 75 indicators of a professional teaching.

The rest of the models of teaching were dissected and classified into the second group keeping direct emphasis on socio-cultural and human values in mind. The second group of models of teaching was formed with regard to their nurturing effects on students' values and growth. The presumption on the one hand is that if teaching takes place using the models with instructing effects in mind then the result would be its effects on nurturing students socio-cultural and values. On the other hand, the presumption for an effective instruction is also that the nurturing models of teaching enhance the instructional effects of the first group of models of teaching. These two presumptions are interrelated. With the use of the nurturing models of teaching as a base and bed for getting use of instructing models of teaching the class environment is enriched to improve students learning in all dimensions of development.

In using the group investigation model of teaching or role playing in the class situation, as an example, students are empowered to work better together and be motivated to make discoveries and use their creativity. Therefore, it affects indirectly the instructional effects on students' learning improvement. The data were gathered through the studies on these nurturing models of teaching for the reason to justify, support and supplement the instructional effects of the models.

The second group of models of teaching with nurturing effects includes:
1- Partners in learning- from dyads to group investigation;
2- The study of values- role playing and public policy education;
3- Jurisprudential inquiry- learning to think about social policy
4- Nondirective teaching- the learner at the center;
5- Developing positive self-concepts- the inner person of boys and girls, men and women;
6- Learning to learn from mastery learning;
7- Direct instruction (Joyce et.al.2009). Through using the nurturing model of teaching the affective skills of students will promote and enhance their understanding of instructional concepts much better.

Steps used in a new master approach in teaching

This new approach has five steps as shown in Table 1. Step one is designing a map for titles and subtitles of each chapter of the existing texts considering the critical concepts in mind.

Table1. Step by step approach in teaching with instructional and nurturing effects in mind

1-Map of the concepts in the existing curriculum	2-Modified Map of the critical concepts, indicating which concepts best accepts which model of teaching and technology?	3-Preparing learning environment indicating Which study methods fits learning modified curriculum?	4-Leading student's active involvement in a curriculum that is harmonized with instructional and nurturing effects on students	5-Measuring information processing skills, knowledge and socio-cultural and human values

Table 2 shows the scattered titles and subtitles of the first chapter of "Supervision" course in the department of educational administration, as an example. The critical factor in this example is the fact that curriculum planning and the models of teaching are combined and integrated in these steps. There is an underpinning fact of this research which demands professional skills of teachers to become able to make use of curriculum planning to match their lessons contingent upon students' needs and class situations. It shows who is professional and competent to maintain the profession on the route of fulfilling educational goals. In the traditional and existing situation it is rare to see the teacher play the role of curriculum planner adopt teaching model and match it with the academic subjects and suitable technology for the improvement of students' learning. The teacher shows professional competencies as commitment to the educational goals of bringing up a well developed whole body of individual students. Through using the steps in sequent (i.e. mapping the concepts in the existing curriculum, preparing modified and desired map of the critical concepts, indicating which concepts best attracts which model of teaching and technology, preparing learning environment indicating which study methods fits learning modified curriculum, teachers lead student's active involvement in a curriculum that is harmonized with instructional and nurturing effects on students, and at last measuring information processing skills, knowledge and socio-cultural and human values. The consequent steps are: designing an ideal map considering the curriculum planning tenets such as hierarchical and horizontal liaison, and integrity of critical concepts, considering feasibility for teaching in the new map, selecting models of teaching and suitable technology of education involving students and managing class environment for learning, implementing the approach and evaluating its instructional and nurturing effects on students. The students are asked to participate in curriculum plan, selecting models of teaching and suitable technology for learning critical concepts of chapters, titles and subtitles of the texts.

Sample courses using the approach

So far the master model of learning that overhaul learning activities of any class has been explained in theory. The model has been used in practicing teaching four academic texts with 54 chapters in the graduate school of education namely, Theories of Organization_and Management (Scott Rechard, 2003), Models of Teaching (Joyce, Bruce and et.al, 2009), Strategic Management Information Systems, and Techniques, (Rowley 1994), and Supervision, A Guide to Practice (Wiles, Jon & Bondi, Joseph 2004) have been experienced. The practice has been started from two years ego and it is deemed to be continued for two more years.

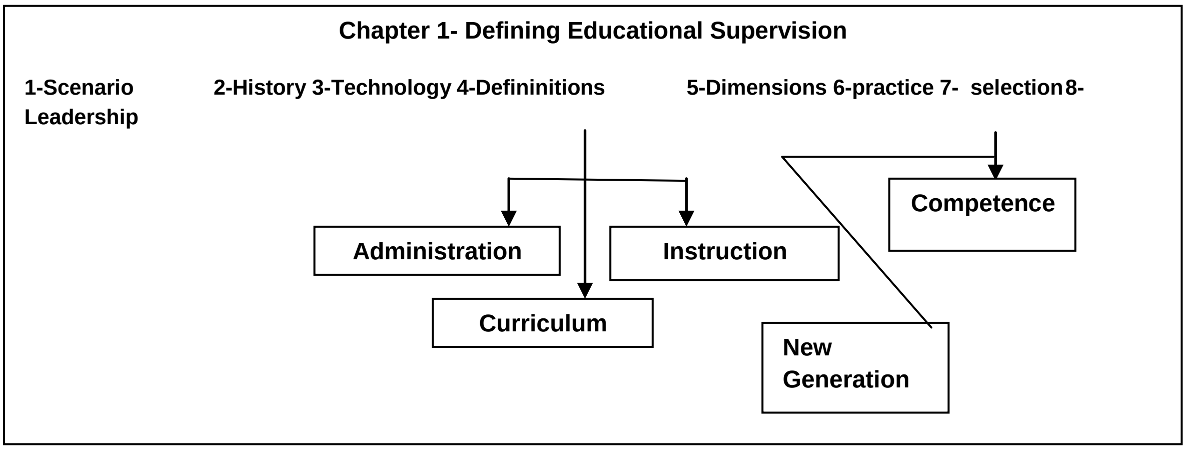

Table 2- scattered titles and subtitles of chapter one of the book "Supervision" in Bondy et.al 2004

Table 2 shows very scattered 8 major titles in a very general term. It is difficult for students to maintain them in mind because of their dispersion. It is not very easy to remember them, connect them in mind, construct knowledge, and get a clear map of meaning in mind from them. In Table 3 a new mind map shown with five general terms is considered very meaningful and likely to be taught and learned.

Table 3- six dimensions for chapter one defining Educational Supervision

As an Act of administration	**As an act of curriculum work**	**As an of Instructional function**	**As an act of human relations**	**As management**	**As a generic leadership role**

Table 3 shows a summary of the chapter content in a new mind map constructed to give the main idea of the chapter. It works as an advance organizer and links the main title of the chapter, and five titles derivative of the whole chapter. In this way the instructors are able to make the changes in curriculum and provide a new map having the class environment, model of teaching, suitable educational technology and existing understanding of their students together in mind. The aforementioned curriculum development is used now for managing the use of models in teaching. In Table 4 one could consider the cross interrelated models of teaching and the main title of each chapter.

Table 4- Mind map for matching 7 models for instructional effects (from Joyce et.al 2009) with 10 chapters of Supervision (from Bondy et.al 2004)

Models → Chapters ↓	inductive	Concept attainment	Picture-word	inquiry	Memorization	cynectics	Advance organizer
Defining supervision				MEAN= 55.13 S.D=6.621			
foundations						MEAN= 62.7 S.D=7.843	
Professional knowledge					MEAN=64.38 S.D=7.354		
Designing curriculum	MEAN= 64.38 S.D=7.354						
evaluation			MEAN= 64.38 S.D=7.354				
Human relation		MEAN=55.1 S.D=6.621					
Staff development			MEAN=64. 38 S.D=7.354				
Administrative function	MEAN= 51.6 S.D=5.841						
New direction				MEAN=55.1 S.D=6.621			
	MEAN= 51.6 S.D=5.841						

Table 4 shows the act of teaching and using a model of teaching in each chapter. As was mentioned before, the findings have not been completed. It is only an example of how to make the work going a head. The 72 indicators are being used and statistics of mean and standard deviation have been calculated for a few experiments arbitrarily as have been shown in each box of the Table 4. The Table is only an exemplary sample of the trend in using master model of teaching. There are blank boxes in the Table because the study is underway and still needs the results of many case researches to come up. One should take into consideration that Table 4 is an example of how to use models of teaching in a course of study regarding its content during one academic term. It is under construction in regular successions. The effect size of the teaching through the approach is significant. This trend of mind mapping can have several advantages as follows:

1- It can be used as data-base or storage of expert knowledge with new information implying expert system application in curriculum development.
2- It can be improved in each academic term through action research and feedback on the instructional and nurturing effects on learners.
3- It can be used by the next generation of students that take the course for seeing the process of producing knowledge
4- It is flexible for grasping and adding new material to bring the content up to date

5- Students see a clear route for searching different sites and add to the already existing material.
6- The result of any need assessment for related content and improving the quality of the courses in the department of educational administration toward fulfilling of the goals can be taken into consideration.
7- The process and the cycle of clinical supervision (planning conference, class observation, and feedback conference) could be planned for teachers to improve the instructional and nurturing effects on students.

The result of any need assessment to related content in improving the quality of the courses in the department of educational administration toward fulfilling the goals can be taken into consideration. To prevent the article from being too long of the normal size, as Table 4 shows "Supervision" as one of these books with 10 chapters is considered arbitrarily. Table 4 explains how the teaching will be provided in more details with regard to the titles of each lesson. The master model approach reiterates the use of participation model of teaching and advance organizer model of teaching in the entire teaching plan of all the chapters of the book. Inductive model of teaching has also been approved for its general uses and effects in teaching. It is possible to combine together picture-word inductive model of teaching and inductive scientific model of teaching to enhance more effect size. Table 4 has not been completed. It identifies research still to be completed. The process of case study research is continuing to complete the Table since the research style is longitudinal and takes two more years to be completed. The Table works as data base form (kind of data used in expert system) for storage of expert ideas on the instructional effects of models of teaching across the chapters of the Supervision book. There are 110 graduate students in educational administration department who are potentially involved in action research to conduct teaching according to the approach and scenarios that are prepared in the four courses. The statistics noted here have been provided from 15 students participated in the course of supervision. They are used temporarily for the purpose feasibility and should be improved with gathering more data on implementing the approach in more academic coming terms in all the four courses in educational administration. There is also the possibility to use pre and post testing on their understanding and compare their success with the traditional way of teaching. For these points of views, therefore, it is necessary to work on producing different suitable tools for measuring instructional and nurturing effects on students learning and development. Although, the 72 indicators are used to show the instructional effects of the approach and although the 100 indicators for nurturing effects are used as a tool for measurement of the effects, there is a need for pencil and paper teacher-made test too for comparing academic achievement. There is also a need to improve standard items to show the indirect effects or nurturing effects of the teaching approach.

In Table 4 one can see the statistics related to implementing models of teaching in teaching chapters of the "Supervision" in an academic term with the class size of 15 students. The calculation was done using SPSS version 15. Using eclectic models of teaching was intended but with emphasis on each model in each session. 'Advance organizer' and 'Partners in learning' were the common models of teaching used in all of the lesson plans and their implementation.

METHODOLOGY AND RESEARCH PLAN FOR FOUR YEAR'S LONGITUDINAL SEMI-EXPERIMENTAL TEACHING IN FOUR GRADUATE COURSES

The cohorts of graduate students attending the school of education in the past two years were considered to be taught according to the approach. At the beginning it was done arbitrarily and with hesitation to be successful in managing the class for the changes to occur. The trend in this approach clarifies that each student takes the leadership role in conducting the teaching for the designated chapter according to the selected scenario of teaching. In each scenario there were specified models of teaching and critical concepts of the chapter (see Table 4 as an example). Suitable educational technology is used and accommodation for its use is prepared.

There are a lot of flash carts each prepared for critical concepts in each chapter. They are prepared by students with the help of the instructor and are used mostly for students' engagement, pear group and partners in learning and participation in the process of gathering data, classifying the data into information, coming up with the specific and critical concepts in each title, analyzing together the concept in search of finding and classifying features of any cases belonging to the concept, creating definition for the concept and being prepared to anticipate the belongingness of unknown cases to the concept definition. This trend and process of learning through gathering data and making information and defining the concepts for further application was an intellectual skill of learning that students were expected to master in learning different subjects.

The instructional effects are assessed through a researcher - made questionnaire of 250 items which was reduced to 72 items through statistical reliability and validity tests. The Professors Committee of Experts and Cronbach Alpha were used for this purpose. The Effect Size formula {ES= (average of experimental group--average of control group)/ standard deviation of control group} is used to see the significant differences of the new approach of teaching in comparison with the traditional and existing teaching approach. The nurturing effects are assessed through the second researcher - made questionnaire using 100 items referring to the socio-cultural and humane effects in three categories (i.e. personal, social and behavioral) on students' attitudes.

The findings are discussed with all the cohorts of graduate students' researchers who participated in the research. Each one prepared their research findings on the effect of conducting the teaching approach in their related subjects. The 72 indicators of instructional effects that measure the students' attitude toward the acceptance and desirability of the approach are implemented. As shown in the Table 4, the search has not been completed since it is a longitudinal approach and needs more feedback and evidence to be summed up in the final conclusion.

The approach continues to be implemented with the next cohort of graduate students and for stronger ratification. As a matter of fact, the approach acts as an expert system to accumulate the results of each conduct in its storage data base and use feedback for improvement through new implementation. Although the research see the instructional and nurturing effects of the approach regarding changes in socio-cultural and human values on personal, social, behavioral, and information processing skills and the results are already successful, able to be generalized therefore the approach is suitable for teaching other courses in the sustainable trend of improvement.

Furthering this research there is a need for questionnaire items to be categorized and analyzed using factor analysis to prepare a reduced questionnaire through using the critical factors for suggesting suitable, flexible, and comprehensive model for teaching and learning of all subjects in different branches of knowledge in science and technology education. The approach then will be considered in curriculum planning and teaching scenarios in each of 54 chapters of the four academic books in the graduate department of educational administration.

The instructional and nurturing effects of the teaching according to Scenarios will be analyzed through using SPSS software. The significant finding is that the use of the approach could be generalized not only for the graduate school of education but for teaching and learning science and technology education as the whole.

CONCLUSION

Although the aforementioned explanations and steps taken to carry out the approach have shown the feasibility of making arrangement for the changes, there is still the need for supportive actions and supervision to generalize the approach for use at different courses and levels of education. In this student - oriented rather than teacher - oriented approach students are not only learning the critical concepts of the lessons better but their skills to cope rationally with socio-cultural and human values will be increased. The presumption that instructional effects of this approach enhance the nurturing effects and vice- versa is a good indicator that focuses on one of the most negligent factor in the history of education.

The approach will help put juvenile intelligence on old shoulders rather than putting old head on young shoulders. The instructional effects are stored in 72 indicators and the nurturing effects in 100 items questionnaire which have been provided in an in-depth study of the literature. These items have been discovered through cross cultural studies and the analysis of different scenarios of teaching and could be used as a standard of a successful teaching. They have been shown reliable and valid through calculated statistical approach and are known secured to be used. Some of the items that measure the instructional effects on students are: understanding the process of attaining concepts, obtaining the skill of classifying data to make information, creating definition for unknown phenomenon, overview of the process of producing concepts, making connection of new concepts with the mental construction of knowledge, enhancing self education, using meta-cognition in learning, improving self scientific observation, increasing the memorization potential, being able to weigh alternative for solving problems, using critical thinking approach, learning the way that scientist use for developing the concepts, learning inquiry approach in solving problems, internalizing learning, linking known concepts with unknown materials, reconstructing the new images of concepts, and so on.

The items on nurturing effects are more important than instructional effects mostly because they are sustained in one's whole life. Their final effects should be calculated by multiplying their effects by the time they are used in whole life. Some of the nurturing items that affects students' behavior are also: having mutual understanding in learning, finding self in the field, improving inquiry inclination, improving critical thinking, maintaining patient and tolerance in critical situation, using comprehensive, flexible and penetration in discussions, being self directed person, having individual self–awareness, evaluating new concepts, understanding feeling of themselves and feelings of others, using sympathy and empathy in relation to others, understanding their uniqueness, feeling internal rewards for understanding, self evaluation, learning independently, having a positive attitude toward themselves, acting on the base of rationalized accepted values, being aware of social and individual values, having respect for others, improving human relation, having a life philosophy, finding the meaning of self in life, being patient in evaluation of others' idea, working in a group of peers, being motivated to learn and doing according to their logical understanding and so on.

Using the approach makes a significant change in the trend of already existing teaching, improves the quality of teaching and the curriculum, and lets students to be improved in learning with a good motivation to learn. It is basically oriented to students' learning improvement and works with students' involvement in all the process of attaining concepts and learning. The results of the approach have been so far so good to be implemented in teaching not only the aforementioned four courses but in all grades and levels of education. There are a heavy burden of its implementation in teaching other subjects and it need supportive action from educational administration and educational systems for making general policy to carry it out.

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COMBINATION OF REAL AND VIRTUAL ENVIRONMENT IN EARLY CHEMISTRY EXPERIMENTAL ACTIVITIES

Martin Bílek

Department of Chemistry, Faculty of Education, University of Hradec Králové, CZ

martin.bilek@uhk.cz

Petra Skalická

Department of Chemistry, Faculty of Education, University of Hradec Králové, CZ

petra.skalicka@uhk.cz

ABSTRACT

The combination of real and virtual environments in general science education is a current challenge for school curriculum in the period of information society. The paper describes theoretical background, starting points and design of a research project in this area. Possibilities of real and virtual school chemical experiment and their combinations will be analyzed. They bring a new dimension not only to laboratories, but also to everyday life of students, teachers and everybody interested in science education. New possibilities to measure, to control anything from any computer, to receive current data from the opposite part of the world – these are incentives of strong motivation. The project design, including pilot results, is presented on the example of laboratory work "pH measuring". Two as much as identical scenarios were prepared using either real or virtual pH-meter, managed by worksheets containing tasks of three levels: pH measuring of different solutions, answers to problem-based questions and open-task to create a set of next pH measuring. The first received results are presented and discussed in this article.

Keywords: *Early chemistry education, experimental activities, general science education, combination of real and virtual chemical experiment, simulations, pH-measuring*.

INTRODUCTION

Currently the real life brings more and more virtual environment items, new virtual worlds etc. Both children and adults are strongly motivated by experimenting, discovering and understanding things in their own way. The school experiment is to be purposeful, i.e. clear, appropriate to pupils´ age, simple, well organized, visible and safe. Is the remote or virtual (simulated) experiment able to meet these requirements? The objective of our research project is to determine possibilities and their limits in the use of virtual environment supporting early science education, paying special attention to the early chemistry instruction. It means to research effectiveness of computer simulations and natural science (chemical) animations applied in early chemistry education (basic school, grades 8 – 9, 13 – 14 year-old pupils), either independently, or in various combinations with the real experiment. The core of the research is to discover the relations and provide recommendations for meaningful and effective use of computer simulations and animations, remote and virtual laboratories, etc. (Bílek et al., 2009).

THEORETICAL BACKGROUND

The orientation of natural science instruction (including chemistry) towards methodological tools in natural science cognition, i.e. empirical methods (e.g. observation, measurements, school chemical experiment), and theoretical methods (e.g. modelling), originates not only from its basis and subject of chemistry as a scientific discipline, but mainly from the characteristics of the methodology. When researching chemical features of substances or phenomena, it is necessary to join both empirical and theoretical processes in running a real experiment as the most powerful methodological means in natural science cognition. Its position is unsubstitutable even in the chemistry instruction, where it appears in various forms, e.g. it works as s demonstrational and pupils´ experiment, and provides:

- motivation,
- starting information about the studied object,
- information on veracity of the learning content.

The following tasks are to be solved, so as experimental activities can be improved and a wide range of functions in the process of cognition emphasized:

- defining single phases of observation focused on finding basic features of the observed objects or system,
- working out the process of cognition, including the thought experiment in chemistry, which is understood to be a certain form of modelling,
- analyzing an experiment as a method of cognition, mainly from the point of its function in the process of cognition,
- aiming at practical activities when running the experiment in the problem-solving instruction.

Certain results have been received from the works which deal with the position and functions of current chemistry methodology elements and other natural sciences in their didactic systems. Following aspects and approaches may appear, e.g.:

- relation between the problem-solving principle and the system of experimental activities in chemistry instruction,
- mathematics and logic in the methodologically run chemistry instruction (mathematics as a methodological tool in the process of natural reality cognition),
- modelling and models in teaching chemistry and other natural science subjects,
- the issue of the development of material didactic means for methodologically oriented chemistry instruction.

This area also includes innovations of material didactic means. Attention is paid mainly to those supporting school experiments with data administered by computer, computer simulations in the form of web applets, remote and virtual laboratories.

The subject of chemistry is again affected, as it was in late 1980s, by discussions on new content, questions on the effectiveness of organizational forms, methods and procedures, adequacy of applied didactic means. It keeps on emphasizing general rules defined by Hellberg (1983) which call for:

- increasing the demands on abstract thinking in the process of instruction,
- removing unimportant items and emphasizing general character of single subjects,
- learning to understand the given subjects in relation to similar ones.

This requires increasing effectiveness and frequency in using the essential methodological tool of natural sciences, i.e. the school chemical experiment, and at the same time applying new didactic means, mainly those on the digital basis.

Methodological aspects cannot be omitted even in applications of information technologies in the science (chemistry) instruction. Starting from this point of view, the basic and general methodological tools (methods) are as follows:

- empirical methods: simple and controlled observation, real experiment, work with empirical hypothesis,
- theoretical methods: thought experiment, modelling on different theoretical levels (material, mental, mathematical), work with theoretical hypothesis.

Simultaneously it is possible to advocate that two sciences function each other as methodologies, mainly in situations when the science reflecting simpler fields of phenomena carries out the function of a methodological tool towards the other science which solves more complicated problems. Thus Physics is the methodological tool towards Chemistry, and Chemistry towards Biology. Sometimes another situation may appear - a more abstract science, e.g. Mathematics, is the methodological tool towards the other sciences (Hellberg and Bílek 2000).

The function of the interactive medium is not directly, but vicariously methodological. It enables to apply basic empirical and theoretical methods in a faster, more complex way, and to save their results into memory in long-term periods, and to provide information on the history of the studied phenomenon at any time. This is a substantial auxiliary tool allowing improving methodology of gaining new and applying still existing pieces of information.

When considering the above presented aspects, computers have an important role in connection to any other basic empirical or theoretical methods, or in mutual relation between them. Above all, they can work as a database of information gained in continuous monitoring, or control processes on all quantitative levels – laboratory (micro-, semi-micro-, macro-) instrumentation and operating. This is the main way of ICT implementation in natural science practice. They serve as a tool enabling (Hellberg and Bílek 2000):

- numeric operations (similar to high-level calculator);
- monitoring, continuous assessing and saving data to memory after "live" observations (controlled observations) and real experimenting;
- modelling of these procedures – and working as their simulator; it assumes there exists a mathematical model of the appropriate methodological procedure; the model is the starting point in creating the appropriate simulating programme;
- a wide range of other possibilities in modelling activities which the computer is used in, especially creating the model, in case of simulations applying the model, and interpreting it;
- complicated examples, when a large extent of information on the given class of things, objects, substances, phenomena is inserted and computers work as advisors (experts) in the given field – expert and knowledge systems.

The particularity of natural sciences, and especially chemistry, lies in the sphere of observation of the course of chemical experiments (sensoric area) and in forming conditions for their repeating and changing (motoric area). It is obvious that intellectual activities are a necessary part of every sensomotoric (or either sensoric, or motoric) activity. This topic has been dealt by numerous authors, e.g. H. Riedel (e.g. 1990, 1991, 1992, 1994) worked out the theory of internal operations. He distinguishes:

I. Cognitive operations - operations when information enters the mind:

- cognition - from the surrounding world,
- recalling - from memory.

II. Production operations - operations of processing information:

- forming - operations of further transferring and structuring:
- remembering - transferring to memory,
- evaluating - observations in mind,
- transforming - forming operations and connecting them into new information,
- model-oriented - a model, continuity, planning,
- convergent thinking – depending on a certain thinking pattern,
- divergent thinking - not depending on the original pattern in favour of other ones,
- spontaneous thinking - without any pattern, by leap:
- original way of thinking.

The above presented types of activities are applied in both procedures (theoretical and empirical) of learning any topic. The dominant (or initial) activities in the theoretical procedure are the intellectual ones, in the empiric procedure – sensomotoric activities. The simplified analogy of both procedures in displayed in the schema according to Čtrnáctová (1982) (see Fig. 1).

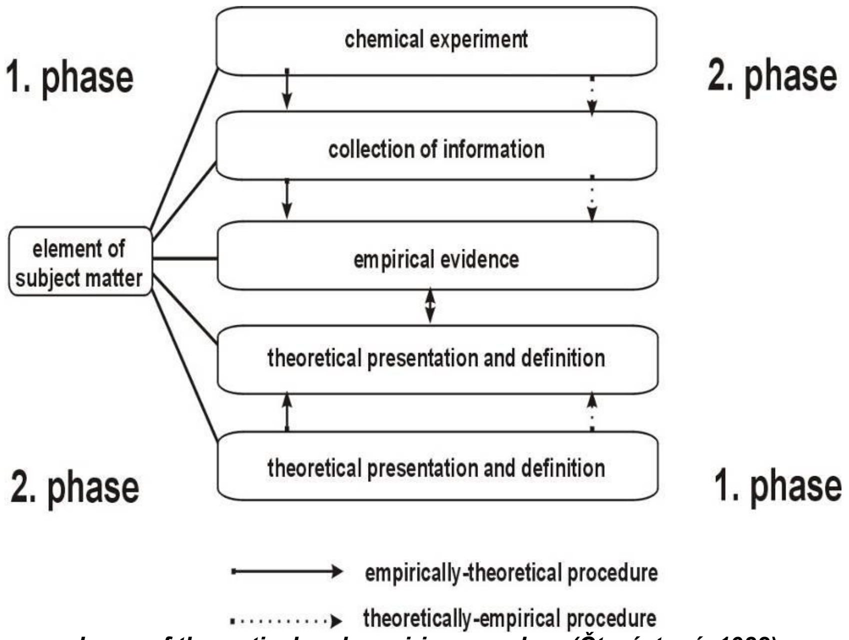

Figure 1 Two-phase schema of theoretical and empiric procedure (Čtrnáctová, 1982)

The schema proves that the procedure and evaluation of the chemical experiment are analogical. That is why pupils´ activities, when running and evaluating the experiment, and in theoretical explanation of the given pieces of knowledge, are similar. The difference is shown in teacher´s activities, i.e. in the way of directing the appropriate phase of the educational process (Čtrnáctová, 1982). The above mentioned pieces of knowledge are concretized in a model by Hellberg (1983) which does not reflect basic methodological tools of cognition, but natural reality in the process of natural science education. The following schema (Fig. 2) displays structuring into two fields. The sensory-concrete field of thinking is on the left, the concrete thinking is on the right. The fields may be also called "inductive-concrete thinking" and "deductive-concrete thinking".

As it has been indicated above, computers and other information technologies can be used as useful supporting means of emphasizing methodological aspects of natural science instruction. According to Fig. 2, they are mainly as follows:

- support to running experiments and modelling (computer - A),
- support to directing empiric and theoretic hypothesis defining (computer - B),
- support to forming empiric and theoretic items of knowledge (computer - C).

Information and communication technologies play the role of traditional didactic means which aim at optimizing educational conditions, i.e. support planning, projecting, running and evaluating instruction so that the educational objectives were reached, and reached in an effective way. Opponents emphasize the factor of the learner, which is missing or considered a passive object of learning. In our latest monograph (Bílek et al., 2009) we are trying to outline the meaningful combination of the real and virtual environment in the natural science (chemistry) instruction which is one of the crucial conditions in the process of innovation of school experimental activities.

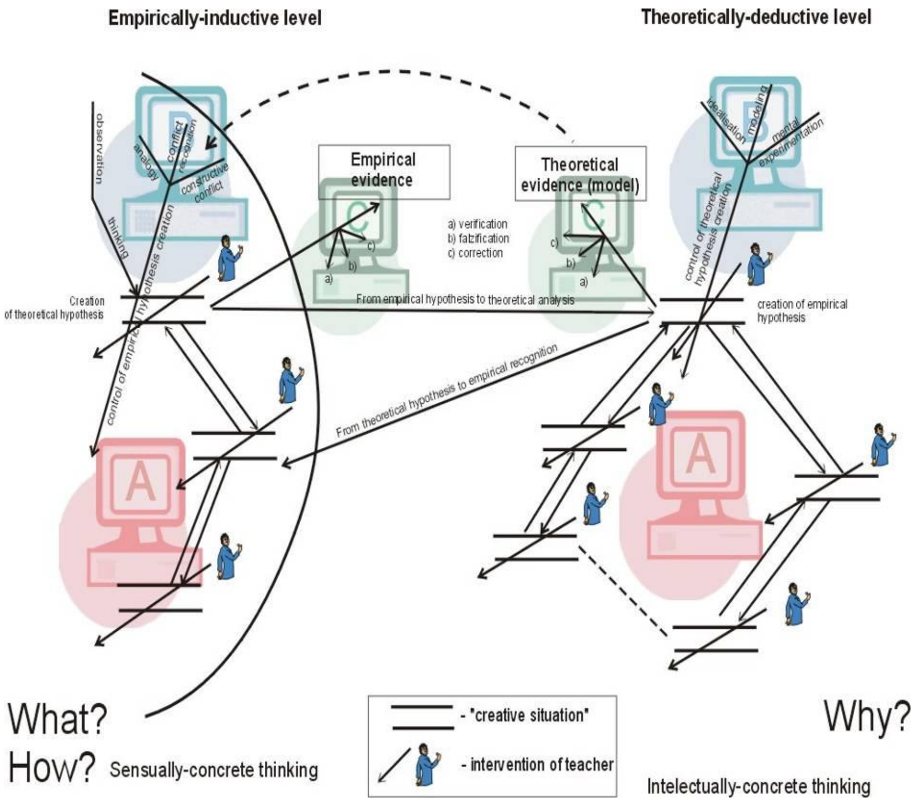

Figure 2 Model of basic methodological tools of learning natural reality in natural science education accompanied by various types of computer support (Hellberg, 1983, Hellberg and Bílek, 2000)

PILOT RESEARCHES AND FIRST RESULTS

In the first part of the research project various proposals combining a real and virtual experiment were designed and considered by chemistry students and teachers who participated in the courses "Computer supported school chemical experiment" and "Chemical educational software" at the Chemistry Department, Faculty of Education University of Hradec Kralove (Czech Republic). Totally 78 students of the 4th and 5th years (study programme Teaching Chemistry) evaluated four combinations below:

- simulation after real experiment for explaining its principle,
- simulation after real experiment for fixing knowledge,
- simulation before real experiment for explaining its principle,
- simulation before real experiment for training the activity.

Acid-base titrations, experiments with galvanic cells, measurements with spectrophotometer and pH-meter were used as examples. Most students preferred running the real experiment to the virtual one, and mainly using the simulation of experiment for explaining its principle. It was interesting that students did not consider the "training" role of simulations to be important for practising work with laboratory apparatus, understanding principles of laboratory procedures etc. (Bílek and Skalická, 2009).

In the second part of the research project the main topic refers to experimental activities of pupils in general chemistry education. The basic school pupils undergo a pilot research on laboratory pH measuring supported by real and virtual (simulated) apparatus, i.e. a virtual pH-meter, which is an available simulation on T. Greenbowe Web page (Greenbowe, 2009), and a hand-operated pH-meter in real set on the laboratory desk.

After lessons "Acidity and alkalinity of solutions" two as much as identical scenarios were prepared using either real or virtual pH-meter, managed by worksheets containing tasks of three levels:

Level 1: simple pH measuring in three samples of selected chemical substances (hydrochloric acid, sodium hydroxide and sodium chloride) in three different strengths.

Level 2: answers to problematic questions followed by verifying them by measuring changes in parameters of the substances (concentration, volume, similar chemical substances), e.g. What pH value will a certain volume of hydrochloric acid solution reach having lower/higher strength than in the previous measuring?, How will pH sodium hydroxide with strength of 0.06 mol/dm^3 change when its volume increases from 100 ml to 150 ml?, What pH value will potassium hydroxide solution reach in comparison to sodium hydroxide solution if the strength is the same?

Level 3: open task, e.g. Design and describe assignments and results of other tasks which you could do with the provided aids and real or virtual chemicals. You can ask your teacher to provide you with other chemicals and aids for the real experiment, or give you advice on other functions of the simulated pH-meter for the virtual experiment.

The following hypotheses were set for this research: (1) No statistically significant differences will appear in pupils´ results of pH-measuring in provided solutions of chemical substances with the real and simulated pH-meter. (2) No statistically significant differences will appear in pupils´ answers to problematic questions dealing with pH-measuring in solutions of concrete chemical substances by the real and virtual pH-meter. (3) Pupils´ recommendations on using the laboratory arrangement for other measurements will be more frequent and varied, i.e. more proposals will appear, and the teacher will be asked more questions relating to the real environment than to the virtual one.

The pilot research ran at two basic schools during compulsory laboratory lessons in Chemistry. Totally 85 pupils (four groups) of 8th grade (13 – 14 year-old) participated. The applied method was the pedagogical experiment of crossed groups, i.e. two groups started work with a real experiment first (see Fig. 3); two other groups started with a virtual measuring (see Fig. 4). In the next lesson (3 days later) the groups changed the environment.

Figure 3 Pupils working with real pH-meter

Figure 4 Pupils working with virtual pH-meter

Pupils worked in the same groups of two or three during both parts of experiments (virtual and real). Having finished the lessons their worksheets were analyzed on all three levels of tasks. During the lessons pupils´ reactions were recorded, e.g. types of questions, which should help to modify the worksheets and provide methodological recommendations for the follow-up research with a wider group of respondents, which is planned for the 2010 year.

The analysis of pupils´ results on Level 1 unreservedly verified the hypothesis. In pH values collected from real and virtual pH-meters no statistically significant differences appeared. On Level 2, which focused on problem-solving tasks based on previous activities and pupils´ common experience, statistically significant differences were identified between groups working in either real or virtual environment in the first round of measurements. Consequently pupils applied the experience they had received in the first round. Their results were better and statistically significant differences were not proved. Results of Level 3 were tensely expected, as they were to provide proposals for follow-up measurements, procedures, explaining consequences etc. Based on experience we expected the real environment to provoke wider variability of proposals than the primarily varied, but limited virtual environment. The reverse was true. More proposals were recorded just in the virtual environment. Although it was obvious from direct observations, pupils asked more frequently about other possibilities of working with the real pH-meter, they did not write down the questions to the worksheets. Generally it must be said fewer than half of respondents (43 %) filled in this part of the questionnaire only.

The pilot research of the influence of the real and virtual environment on pupils´ experimental activities proved our assumptions to a considerable extent. So that the research could be applied on a more numerous sample group, several small changes of worksheets were identified, and an essential one – the hypothesis relating to Level 3 must be redefined towards using stronger motivation of the virtual environment.

CONCLUSION

The feasible real experiment should not be in any way eliminated from school laboratory practice. Forming and improving manual skills (measuring by available laboratory instruments, working with laboratory systems, even constructed from common subjects of everyday use, working with safe substances), which are substantial part of natural science education, cannot be fully replaced by practising through monitor and keyboard. On the other hand it is impossible to avoid indirect observations and working with models and instruments. Researching these fields leads, or not, to proving intuitive estimations, which is important, as well as answering other questions resulting from this area of potential assets and threats.

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BIOLOGICAL EVOLUTION TEACHING RESEARCH IN A SOCIOCULTURAL PERSPECTIVE

Nelio Bizzo

University of São Paulo

Bizzo@USP.BR

ABSTRACT

History of Science can provide not only good ideas for classroom practice, but also can throw light on educational research. The main problems scientists faced in the past can be similar to those students find today. We present results of a historical reappraisal of the process of elaboration of evolutionary theories, showing that the conception of deep geological time, contrary to what is generally admitted, had deep roots in the ground Charles Darwin was planting with his first thoughts on natural selection. Marine fossil remains in mountains had an original interpretation in Italian geology the century before, which had been fully incorporated by the geology of Charles Lyell. He was sure about the antiquity of our planet, and Darwin decidedly relied on him. The certainty of the antiquity of earth that emerged in the 18th century relied to some extent on the findings of a place where fossils are very well preserved and plenty of clear evidence of past environmentsexists (*Konservat-Lagerstätten,* literally "place of storage). This place is a small village, which invites visitors to revise their conceptions about the history of earth. We conducted interviews in this place with young students, in order to understand their views on geological time. Results show that interpretation of evidence follows different ways, as young students give several meanings to the extraordinary fossil remains they find every day. In addition, elements from History of Science suggest the need for a revision of the historical framework in which evolutionary theories are commonly seen in school settings and urge educators to pay more attention to scholar scientific definitions offered to students, which can give rise to unnoticed complex intellectual ecologies in the school context.

Keywords: Evolution Teaching, History of Geology, Geological Time, Science Curriculum Design

METHODS

Schools and educators try to provide understanding of scientific theories to young students, and there is a growing awareness that there is no direct transmission of knowledge from books or teachers' discourse to students' minds. Current instructional approaches for science teaching view learners as active agents in the processes of constructing meaning, which implies taking into consideration what the learner knows and believes on the subject. This set of ideas is frequently named "everyday knowledge" (or lay understanding) and is used by people to explain phenomena in their daily lives. In educational and cognitive psychology literature, such ideas have been described as "misconceptions", "prior knowledge" or "alternative frameworks". The knowledge that people hold is a potent force in determining which sort of evidence is judged as relevant and how information will be perceived. In social psychology, such ideas have been described as "social representations". One of our major aims is to understand processes which give rise to these social representations.

Explanatory statements of science are conceived as having a developmental history, which, together with its epistemological constraints, plays important roles in educators' decisions about curriculum design and teaching plans. Our group carries out research at these two levels, looking for contributions of the developmental history of science core concepts and teaching practices, considering wider social processes of meaning-making which influence students. This multifocal research program relies on what has been called "bricolage approach" (Berry, 2006), as a variety of tools and possibilities are brought together in order to help new understandings of apparently obvious social relations to emerge. Education is admittedly an area where complexity emerges, questioning some assumptions of causal relations, for instance, between teachers actions and student responses. This perspective does not allow isolating an object of the study from the complexity and multiplicity in which it is situated. Moreover, it decidedly does not aim at "solving problems" through the gathering of data which would drive drawing of answers and conclusions.

One of the major steps in these research programs is *problematizing*, in the sense that obvious understandings, apparently undisputable, can be seen from a completely different perspective, focusing upon both epistemic and psychological levels. In other words, clear statements about the historical development of scientific theories ought to be seen as aporetic and near-to-equilibrium teaching-learning conditions should be seen as unstable, trying to avoid a monological, single path or research method. This perspective requires an open-minded understanding – and knowledge – of

> multiple *theories* and *methodologies*, multiple ways to collect, describe, construct, analyze, and *interpret* the object of the research study; and finally multiple ways to narrate (tell the story about) the relationships, struggles, conflicts and complex world of the study that maintains the integrity and reality of objects. (Berry, 2006:90).

We have been trying to avoid the conception of narratives about the historical development of scientific theories of evolution as a crystal clear and objective description of a straightforward process. The historical research follows this path, trying to problematize what is seen as a monological development. There are rich contributions from the field of Critical Cultural Studies, as we recognize complex relationships between power and knowledge, the way knowledge is produced, accepted and rejected, what individuals claim to know and the evidence to which they refer . This brings the learners to the stage, and challenges researchers to understand the internal dialogs which admittedly take place in their minds. Such eclectic view of research involves the use of

> several research strategies from a variety of scholarly disciplines and traditions as they are needed in the unfolding context of the research situation. Such an action is pragmatic and strategic, demanding self-consciousness and awareness of context from the researcher. (Steinberg, 2006:119).

The focus of the present research emerged from previous studies, which showed us the need of a reappraisal of the History of Biology used in educational grounds and the way young students interpret and judge evidence which is traditionally seen as persuasive and unequivocally leading to a certain scientific understanding.

SOCIOCULTURAL CONSTRUCTION OF KNOWLEDGE: HEREDITY

This research program began in 1995, when we first studied ways in which people construct meaning about heredity, focusing everyday knowledge and cognition. Cognitive skills are not fixed and fully predictable, as clear cut results of teaching tasks, but rely heavily on *contexts* (Rogoff & Lave, 1999). Although this understanding is not new, it is necessary to admit that there are many different ways in which the "context" can be defined, as it cannot be seen a structure or features of the task or domain of knowledge. The interpersonal relations and cultural aspects, such as values and beliefs, are important parts of the context in which action is embedded.

Social interaction includes cognitive activity, which implies sharing socially provided tools and *schemas* for action on reality, as

> cognitive activity is socially defined, interpreted and supported. People, usually in conjunction with each other and always guided by social norms, set goals, negotiate appropriate means to reach the goals, and assist each other in implementing the means and resetting the goals as activities evolve." (Rogoff & Lave, 1999: 4).

In the sociocultural perspective cognitive activity is not a lonely and purely logic mental task, but rather a two-leveled process which makes use, on the one hand, of tools for cognitive activity (such as scientific theories) and practices socially negotiated, both related to the past. On the other hand, immediate social interaction creates a material basis for individual cognitive activity. In simpler terms, when one thinks about **heredity**, there are both historical and socially defined inputs, in the form of school books and medical doctors' discourses, as well as relatives and common people's narratives to explain the reason certain traits reached new generations. There are at least two sources of everyday knowledge, in the form of second-hand discourses, which reproduce other peoples' narratives, including repercussion of media diffusion of news, interviews, reports, etc. However, there are first-hand discourses, which focus on the "own life" experience, with narratives with plenty of evidence, referring to knowledge and beliefs.

Knowledge refers to what people know or understand about something, or in Kantian terms, a method that allows the understanding to apply concepts to the evidence of the senses (*schema*). Beliefs can be found in these discourses, as dogmatic social shared notions, which are very difficult to change using discursive and knowledge-based arguments. Obviously, they may vary according to one's academic background, etc., but they are important parts of what we consider *context* in a wider perspective.

We believe these first-hand discourses are more socially supported and may play an important role for the second-hand ones, which can spread knowledge and beliefs reaching a wider social group. However, both may play an important role in the shaping of the knowledge and beliefs students bring to the classroom. When one is asked to explain the color of his/her eyes, there will certainly be a reference to *schema* socially shared which allows to conceive heredity and possibly pending to the knowledge side. More complex questions, such as the reasons some people live longer than others may tend to be explained in terms of beliefs, such as God's will or luck.

Hunt at al (2001) interviewed 61 individuals belonging to families affected by coronary heart disease and concluded that people did not recognize deaths of distant relatives as evidence of genetic problems in the family, but rather attributed them to pure chance. However, when more than one relative was affected, a different picture appeared, as there was some concern about the number of relatives with heart disease on the same side of the family, and this could indicate the effect of heredity. To build their arguments, people often use counter-examples and they are also used to reduce the perceived significance of risks in the family history.

In an introductory pilot study, we interviewed 24 people who attended a genetic counseling service due to the fact that they had children or relatives affected by deafness. These interviews had taken place before patients and their relatives had attended their clinic meetings. The researcher talked to the patients' parents for about thirty minutes in order to collect their ideas. The interviews were semi-structured and asked participants to speak about the origin of the problem. We identified a number of understandings and beliefs of the causes of medical problems, almost all of them pointing to environment as a causal link, especially during pregnancy (Santos and Bizzo, 2005).

We then designed a research program looking for large families with a dominant trait which could not be easily attributed to the environment. In fact, we studied two large families and found very complex and rich narratives in which inherited traits were seen partly due to genetic transmission and partly to the environment, with plenty of evidence taken from second party and direct contact information. They were clearly first-hand narratives, with substantial quantities of evidence (Santos and Bizzo, 2002, 2005).

KNOWLEDGE AND BELIEFS ABOUT EVOLUTION: FIRST RESEARCH QUESTIONS AND SOURCES

Methods developed for the study of conceptions of heredity (Santos and Bizzo, 2005) were applied to design the research of conceptions of biological evolution. Individuals who belonged to families with genetic diseases would be replaced by people who lived near fossil deposits[,] as sources of conceptions using privileged evidence. The first research question was about history of science, referred to the understanding of deep time. When was a solid structured theoretical framework established, on which grounds? Did it involve sound evidence? Another research question referred to learners: what are their conceptions about deep time? How did they judge geological evidence? What are the social views in their environments related to deep time?

A two-leveled research plan was designed, looking for accounts of the development of the theory in History of Science, and for people who had a privileged contact with geologic evidence. A revision of the development of Charles Darwin's published works and letters was carried out, focusing in the perception of geological time, concluding that, in fact, it paved the way for a deeper understanding of the development of life as early as 1835. Document research stressed an important part in Charles Darwin's writings, showing the relevance of geological evidence for the building of the notion of deep time, which could be important for teaching and learning (Bizzo and Bizzo, 2006).

This firm base was possible due not only to the recognized work of Charles Lyell, but also to the authors he admittedly was fully aware of, and derived directly from the 18th century Italian geology (Rudwick, 2008). Darwin's published work soon after the *Beagle's* voyage, more than twenty years before the publication of his major book, clearly shows that he was dealing with the issue of geological time before his first thoughts on natural selection. In fact, he had been reading Charles Lyell's work, in which he advocated a "modern perspective of geological time". However, one who reads Lyell's "Principles of Geology", as Charles Darwin did during the *Beagle's* voyage, finds many quotations of Italian geologists. They would have, Lyell wrote, "ridiculed the psycho teleological systems of Burnett, Whiston and Woodward", written more than one century before, despite the fact that he was almost certainly referring to the recently published work of William Buckland (1784-1856), who had recently published "*Vindiciæ Geologiæ*; or the Connexion of Geology with Religion explained", in 1820, and also his more recent "Reliquiae Diluviae (…)", published three years later. To some historians, Buckland was actually the creator of the creationist movement.

INTERVIEWS: SAMPLING AND DESIGN

As in previous works, we were aware of sampling decisions in the qualitative research process, and how difficult it would be to define groups defined in advance. We were looking for people who lived in places with plenty of geological evidence of deep time, and who knew this evidence in detail and, in addition, could explain their views in an interview. The *a priori* definition of targeting young students relied on the grounds that they could provide their own personal views, which would be comparable to published works as part of the alternative conceptions' literature. However, it was impossible to know how many young students we were going to find at each place, and how important their narratives could possibly be. Therefore, we had to make use of a strategy of gradual definition of sample structure, regarding decisions about choosing and putting together cases, groups and even institutions in the process of collecting and interpreting data. In the qualitative research literature this process is referred as "theoretical sampling" originally developed in the context of research on medical sociology in the 1960s (Glaser and Strauss, 1967, apud Flick, 2006).

In our case, what could be called a representative sample is guaranteed neither by stratification nor by random sampling, but rather by the researcher's perception of the potential of new insights for the developing perspective. In a first phase, it was possible to judge this potential from the knowledge of geological evidence of the place. The main question for selecting data is: "*What* groups or subgroups does one turn to *next* in data collection? And for *what* theoretical purpose? The possibilities of multiple comparisons are infinite and so groups must be chosen according to theoretical criteria" (Glaser and Strauss, 1967, apud Flick, 2006).

Semi-structured interviews were carried out in three different places in Brazil, with students aged 12-16. One place was in southern Brazil, Formação Santa Maria, in a small town where a petrified forest was found (Mata- RS). Two other places were in northeastern region in the Crato Formation, in the Chapada do Araripe region, in the states of Pernambuco and Ceará, and involved students of the same age range. Interviews were transcribed and analyzed, showing rich discourses with explanations about the formation of fossils.

Conclusions showed that fossil formation processes were seen as short-term ones, some taking hundreds of years, despite the fact that a rich paleontological vocabulary was also present in the very same discourses. Terms such as "Albian", "Cretaceous", "100 million years" were often found, but had weak connection to the conception on fossils life span. Jesus Christ and indigenous peoples were frequently referred to as having lived before those animals and plants existed (Bizzo et al, 2006, full interviews transcriptions can be found in Oliveira, 2006).

KNOWLEDGE AND BELIEFS ABOUT EVOLUTION: NEW RESEARCH QUESTIONS AND SOURCES

During field work in Brazil we had collected data which was not initially taken as important as students' interviews. We had unnoticed evidence of social views about geological time in local culture. Artisans sell rocks with engraved images similar of the fossils. Contrary to the first impression, which would present them as simple counterfeit souvenirs intended to defraud tourists, they are artistic representations, which reproduce artisan's understanding of the meaning of fossils. They would be valuable for their intrinsic beauty of forms. These engravings are sold at the house of the artisan, who is proud to say that they are hand made, showing images not only of local known fossils, such as scorpions, dragonflies and insects, but also *Jurassic Park's* dinosaurs and even parrots, disregarding scale in all figures (fig 1a and 1b). These keepsakes express the local understanding of the meaning of fossils, not as proofs of what life was about 100 million years ago, in high Cretaceous, but rather as beautiful forms engraved in solid stone. The notice that a fossil feather was found there, which is presented in the local Paleontology museum, was not understood as a proof of the antiquity of birds in the region (and the whole continent), but took the form of a present-day parrot (fig 1b). So, what we had captured in students' discourse is part of a socially shared meaning of learned expressions like "million years ago", etc.

Figs 1a and 1b. Engraved images produced in the region of the Crato Formation (Brazil).

One possibility to explain previous results of students interviews pointed to the fact that the popular names of fossils in these three places were quite similar to living species. For instance, the fossil remains of trees in Mata (RS) are called by the same name as the living trees (*araucaria*). In the region of Araripe, fossil fish were named as "piabinha", the same as the living fish in small local rivers, which lose all water at least three months in the year – another feature which was part of the explanations about the origin of fossils. Fossilized insects were also named after living ones, for instance dragonfly ("zig zag") and beetles ("besouro").

The similarities between living species and fossil ones in one place, which we called *paleoisomorphies*, led to new research questions. Similar places with striking differences between present day and fossil fauna and flora could possibly lead to different conceptions of geological time, which we called *paleoheteromorphy* hypothesis. Therefore, another research program was designed aiming at finding historic references of scientific discussions in history regarding the meaning of heteromorphic fossils. In addition, we would try to travel to one of these places known for paleoheteromorphies and interview young students there in order to understand their ideas about geological time. Our new research questions referred to finding paleoheteromophic places in the literature of history of geology; and, in addition, we wanted to know if students' views were essentially different in these places. The new sampling would have to follow some constraints, as we would need to find students of similar ages as previously done. Moreover, as one place was found in Italy, we had to face not only questions of transcribing interviews, but also those related to translation.

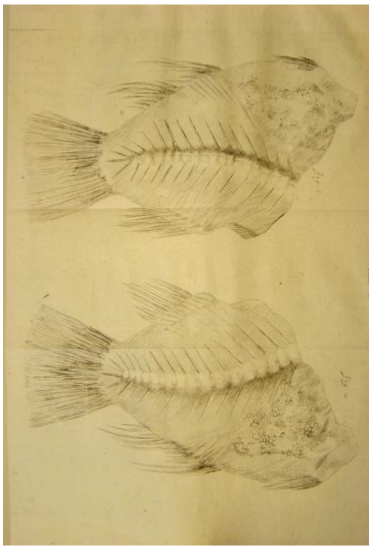
It is recognized that in the context of qualitative research approaches translation involves deeper questions than interviews transcription, as the methodological literature on qualitative research has recognized that the task of generating accurate and meaningful data through translation processes is paramount. The translator is seen as an actual interpreter who "processes the vocabulary and grammatical structure of the words while considering the individual situation and the overall cultural context" (Esposito, 2001,p. 570, apud Marshall & Rossman, 2006). We decided that the same researcher would carry out the translation before the transcription, so that minimal loss of information would be expected.

RESULTS: *NATURE'S INCRIPTIONS DECIPHERED AND READ*

The discussion of the meaning of fossils is a very interesting part of the History of Science and certainly is part of ancient mythologies (Rudwick, 1976). At the end of [XVII] 17th century, as we could see, the Church of England was following theologies which regarded sea fossil remains in mountains as direct proofs of the biblical deluge, and therefore, addressed paleoheteromorphy, as the sea would have brought strange specimens to mountain tops. A turning point can be found in the first years of the 18th century, as debate took place at the French Academy of Science, when Phillipe de La Hire (1660-1718) proposed to regard fossils as living beings which would have lived in the past, as others like Nicolaus Steno (1631-1686) had already proposed, but adding a very special detail. He faced the question of heteropaleomorphy in a quite new approach, without any reference to the deluge, but saying they were transported by water vapor of an underground ocean. Strange fossils would have grown up in the very same places where they are presently found, but inside the rocks, without leaving any external sign. Fossil fish, crabs, lobsters etc. found in high mountains would have been born to microscopic eggs supposedly carried out by water steam all the way up till the hill tops.

This view was criticized by Antonio Vallisneri (1661-1730), who had been a student of Marcello Malpighi (1628-1694), belonging to the school of Galileu Galilei (Rappaport, 1991; Harris, 2009). In his 1727 book "De Corpi Marini che su Monti si Trovano" ("About marine deposits found in mountains"), which brings up de la Hire statements and a study of the petrified fish found in the mountains of Lessinia, in the Province of Verona, which were long known for their extraordinary preservation (Vallisneri, 1727). There are records of the richness of such details, which led many people to describe them as "fish mummies", since the 16th century. A detailed drawing of a petrified fish was included (fig 2a), in order to show that eggs could be seen in the petrified fish, therefore they would belong to egg-producing creatures. In this book, he insisted that the biblical Flood could not account for his ow geological observations, having already developed a reputation as a "non diluvial geologist before writing the first edition of his book. In fact, not only in his book but also in his correspondence, that there existed contradictions, "indissoluble knots", if one compared his own geological views with the Biblical time scale (Rappaport, 1991). Surprisingly, the book received an "imprimatur" stamp of the Inquisition, even if Vallisneri negated the view which attributed the presence of fossils from the sea on the mountains to the effect of the Great Flood affirmed that their presence was instead due to geological transformations, which had led to the rising of lands that had previously been underwater.

The place where the fossils came from was a small village in Italy called Bolca, in the *vicentino-veronese* border, in a place 800 meters above sea level, which is considered a peerless *Konservat-Lagerstätten* (literally "place of storage") or in other words, a place which preserved much of the fossils' details and give a good idea of the whole environment of the past. Without a very good preservation it would be impossible to address de la Hire propositions. There are abundant paleohetermorphic creatures which lived in tropical seas. Palm trees and even cocoa fossils (fig 2b) can be found in that region of the Alps.



Figs 2a and 2b. Page from Vallisneri's book (1727) and a fossil of a cocoa (palm tree fruit) found in Bolca.

This was an ideal place to address research as we had collected data in two other *Konservat-Lagerstätten* in Brazil, namely in the Crato and Santa Maria formations. This was important as we should find Italian students with the same opportunities as the Brazilian ones, who would have had contact not only with fossils, but also with a wider paleontological context. As we will see ahead, many similar details appeared in students' discourse. The discussion of Bolca's paleoheteromorphy can be found in several publications of the 18th century, as Vallisneri's conclusions were confirmed by Lazzaro Spallanzani (1729-1799) almost thirty years later. However, in the words of Charles Lyell:

> A lively controversy arose between Fortis and another Italian naturalist, Testa, concerning the fish of Monte Bolca, in 1793. Their letters, written with great spirit and elegance, show that they were aware that a large proportion of the Subapennine shells were identical with living species, and some of them with species now living in the torrid zone. Fortis proposed a somewhat fanciful conjecture that when the volcanos of the Vicentin were burning, the waters of the Adriatic had a higher temperature; and in this manner, he said that the shells of warmer regions may once have peopled their own seas. But Testa was disposed to think, that these species of testacea were still common to their own and to equinoctial seas, for many, he said, once supposed to be confined to hotter regions, had been afterwards discovered in the Mediterranean. (Lyell, 1835(I), p 77)

In fact, Roderick Murchinson (1792-1871) and Lyell visited Bolca in 1828, and admitted that "the work of geohistory was necessarily interpretative, as nature's monuments could yield little insight unless nature's language could be learned and nature's inscriptions deciphered and read." (Rudwick, 2008).

We have been collecting and reading the production of Italian geologists of the 18th century, which admittedly was the leading earth science of the time. The epistolary debates of Alberto Fortis (1741-1803) (Ciancio, 1994, 2010), and the work of Vallisneri have been very rich sources in order to interpret the ways nature's language was learned in the small village of Bolca, where we performed interviews in the year 2008.

STUDENTS VIEWS: RESEARCH QUESTIONS ANSWERS

Interviews were performed individually in the small village of Bolca, northern Italy, in May-June, 2008. Previous contacts were carried out with the local museum (Bolca's "Museo dei Fossili"), which was visited, and also Verona's "Museo Civico di Storia Naturale" where a larger collection of Bolca's fossils can be found. It is some 30 km away. A semi-structured interview plan was designed and included three parts. The first part had questions about local living species, animal and plants. Other questions regarded local fossils and asked students the name of some of them, showing pictures.

The second part of the interview had questions about three small invertebrates, which were in resin and handed to the students: a large scorpion, and a spider and a beetle which were more or less the same size. We asked students to examine with their own eyes and tell which one was more similar to the spider. The intention of this part of the interview was, first, to investigate their ability to discriminate local living species from exotic ones. The question about the similarity of the spider was intended to see if students answered taking into consideration animal's size, or rather referring to number of legs or any other zoological term, feeling free to give their own opinions. A possible answer mentioning "arachnids" would be taken as a sign that the interviewees were trying to meet researcher's expectations and were not considering their own genuine knowledge.

Students who answered with no reference to formal zoological terms and knew local fossils, were then asked to explain several aspects of their understanding about local geohistory. Students were asked to describe how often they used to go to the local museum, and how they conceived paleoheteromorphy, using examples of known plants and animals. The length of time required for fossilization to occur was another aspect and special attention was paid to any reference to the deluge (which, in fact did not appear at all).

Finally, in the third part of the interview, students were asked to use adhesive labels in order to show their views on deep time, using a pictorial linear representation (timeline), with the word OGGI (today) in one end and the figure of a dinosaur in the other. Red stickers represented local fossil animals, and green stickers represented plants. Once they had placed these two stickers, they were asked to do the same with an adhesive label with the image of Jesus Christ (fig 3a).

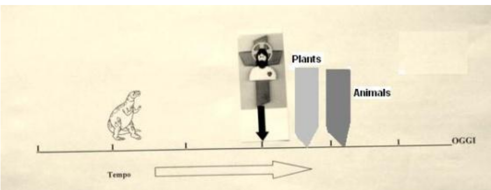
As the village is very small, only six students aged 9-12 years old out of eight qualified for the full interview. The interviews were carried out individually, in their own homes or, as we will see shortly, in the parents' working place. Interviews were performed before their parents; however with no direct eye contact so that the child could not receive positive/negative feedback from his/her parent. Interviews were preformed in Italian (and not in *Veneto* dialect), which is considered the proper form to communicate at schools, and were tape recorded, translated into Portuguese and transcribed for analysis.

One interview can show how rich and original students' views were. Alessia (name not real) is a girl, 10 years old, who was born in the village of Bolca and knows [very well] the local museum very well. She used to play collecting sharks' teeth in a place near her home and knows very well the proofs of the existence of an ancient volcano, which had a crater near the place where the local church is located. The interview was carried out in the place where her father works, in Bolca. In the first part of the interview, she showed her knowledge of local fossils, despite the fact that she did not know local fossils which were not displayed at the local museum. In the second part, which involved the three real size invertebrates on resin, she had as an answer that the spider was more similar to the beetle than to the scorpion, therefore was qualified to go on, as it was a positive sign that she was not simply trying to meet the researcher's expectations. In the first part, she was showed some pictures of Bolca fossils, and asked if she recognized them.

Researcher [showing picture of a fossil plant]: (…) *What about this one... Have you already seen this?*
Alessia: *Yes, but just on pictures* [actually it is not on display in Bolca's Museum, but in Verona's]
Researcher [showing a picture of the fossil fish *Ceratoicthys,* on display in Verona]: *What about this one... Have you already seen it?*
Alessia [hesitatingly]: *Yes. It is the angelfish*.[answer is wrong]

Researcher [showing a picture of the fossil angelfish *Eoplatax papilio* on display in Bolca, considered the most important fossil of the place]: *And what about this one? Do you know this fossil?*
Alessia [positively]: *NO*! [meaning YES!]. *This is the angelfish*! [she is correcting herself].
Researcher: [showing a picture of the fossil fish *Exellia velifer* on display in Verona]: *And what about this one? Do you know this fossil*?
Alessia: *No. This one I do not know*.
Researcher [showing a fossilized plant]: *And this one*?
Alessia: *This is a sort of algae*.
Researcher: *I learned that you know a lot of local fossils! Have you been to the "Museo dei Fossili"?*
Alessia: *Yes, we always go there with schoolmates*.
After answering that the beetle is more similar to the spider than to the scorpio, she was ten asked:
Researcher: *When you went to the* Museo dei Fossili *you saw many plants and animals. Did you have already seen them living outside the* Museo?
Alessia: *No! They do not live here*.
Researcher: *And how was it possible that their fossils were found here*?
Alessia: *Long ago this place was a seashore and there was a volcano here. And the volcano expelled a lot of lava, which burnt animals and some plants.*
Researcher: *Do you mean these animals and plants actually lived here*?
Alessia: *Yes, they lived here*.
Researcher: *They were very different from the one that live here today, weren't they*?
Alessia: *Yes, they were*.
Researcher: *How was it possible that these animals, which were not used to the cold winters you have now, could live here? How is it possible they could survive here?*
Alessia: *Yes, they lived here, 'cause of the volcano, it heated the water of the whole place.*
Researcher: *Ah! I understand. You mean the volcano heated the water, but also the land? The palm trees… We do not find palm trees here anymore… You may have already seen these trees on TV or pictures. They are found only in hot places. Did they actually live here?*
Alessia: *Yes… 'cause of the volcano*.
Researcher: *So… the volcano heated water and land here?*
Alessia [shaking her head positively]: *Yes*.
Researcher: *And how did these animals and plants became rocks? They lived here and there was also a volcano… How there animals and plants became rocks*?
Alessia: *The volcano… There was a lot of lava coming out and it became rocks, and plants and animals also became rocks. But one day, there was no oxygen, and fish cannot live without oxygen. This is why many of them died at the same time. Lava thrown out by volcano formed rocks. Within the rocks there are fish*.
Researcher: *So,* …[thinking] *the rocks in which we find fish were formed by the volcano*… [stating];
Alessia [positively]: *Yes*!
Researcher: *Alright… and there was actually a sea… was the sea here, at this height*?
Alessia: *Yes! It was here, at the top*.
Researcher: *But, how was it possible that the sea had reached this place?*
Alessia: *The whole of the* Pianura Padana [Padan Lowland] *was a large sea*…

The interview explored other aspects, and Alessia was asked to represent her ideas on deep time. Her representation is shown as #2 in fig 3B.



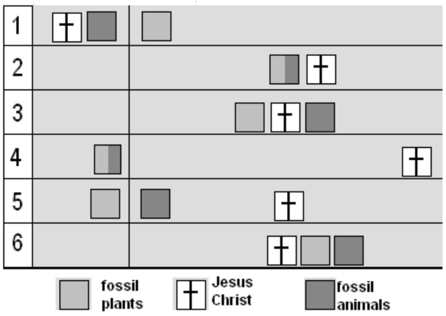


FIG 3a and 3B –Timeline with stickers that students answered (#6) and a summary of the six protocols collected in Bolca.

We were then able to see in objective terms the representation of relative age of the different fossils and time references. Protocol answers are shown in fig. 3b, where we can see several ways in which the local geohistory was conceived. When children speak freely, they show a rich and wide context, generally using a rhetorical expression which is very common in the Italian language, beginning with "*secondo me*" (which means "according to my opinion"). They express complex models, based on very sophisticated evidence available to them, which gives rise to complex intellectual ecologies (Limón, et al, 2009).The oral answers describe a rich knowledge of the Eocene (a term created by Lyell after being there), with two remarkable observations. First, there was no reference to biblical deluge or supernatural explanations; and, second, there was no real acceptance of the description of the uprising of the terrain. Some students declared their knowledge of the "correct" version, but they thought that it was easier to think that the sea had reached that height instead. This is surprising, as we are not facing a religion/belief denial, but a purely rational consideration.

Another interesting model referred to the extinct volcano that can be seen in terms of the abundant basalts that can be found near the local hilltop. A young girl argued that the volcano was once active, and therefore, the local climate should have been hotter; this would explain palm trees and tropical fish found there. There is a surprising coincidence with the arguments used in the Alberto Fortis debate with Testa, as the argument of the microclimate was evocated in 1793 in order to explain local paleoheteromorophy. The "basalt waterfalls" are one of the local attractions for tourists, and provide natural stone bricks, after the action of ice in winter. These bricks were originated from basalt columns, which were described in detail in that epoch (Strange, 1778). Many walls and houses are made with those bricks. This partially explains the reason why the presence of the extinct volcano is so central in youngsters' minds.

As in previous works, we found rich schema, under peculiar ways of interpreting plenty of evidence, and some striking coincidence with similar ways to conceive that body of facts which were used in the past. Our paleoheteromorphy hypothesis showed as not consistent, as there are alternative ways to conceive completely different fossil fauna and flora, without taking into account geological time.

Despite the fact that more research is needed, both in the history of geology and in sociocultural aspects of thinking, results show that geological time is not intuitive and even those who have direct contact with very important and significant fossil remains do not easily construct the notion of deep time. Our conclusion is that there is a need to reconsider curriculum design, and provide students more experience with macro-evolution phenomena, adding new evidence to this proposal as presented in previous works (Dodick & Orion, 2003, Dodick, 2007, Bizzo & El Hani, 2009). Moreover, more attention has to be paid to adult and scholarly scientific definitions offered to students, which can give rise to complex intellectual ecologies in the school context.

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REFLECTIONS UPON ENVIRONMENTAL EDUCATION IN TEACHER EDUCATION PROGRAMS: THE CHALLENGE TO DEAL WITH VALUES

Dalva M B Bonotto

Institute of Biology, UNESP - University of São Paulo State

dalvambb@rc.unesp.br

ABSTRACT

The environmental problems are closely related to our actions involving Science, Technology and the Society that affect our relationship with the environment. Therefore, when dealing with environmental education (EE) it is necessary to reflect upon these relations, identifying beliefs and the values subjacent to them, as well as to work with new proposals that can subsidize new visions, relations and practices. The value dimension of EE is evident when it is suggested that new ways of society-nature relations must be built, necessarily based on values in accordance with those changes. In this paper, I would like to analyze accounts given by teachers in investigative training programs, which point out the challenge for them to work with the proposal of changing the society's common values. Teachers showed insecurity and questions about carrying out this task. Some of them clearly exposed their fears of having an authoritarian attitude to deal with values positioning and not living according to the values they bring into the class. These questions and feelings must be regarded as an important issue concerning teacher education programs related to EE and values education, and must be dealt with care.

Keywords: *environmental education; values education, STSE relations.*

INTRODUCTION

Under the perspective of some authors, environmental education (EE) is linked with several contents and proposals that have already been recommended to science teaching, according to the approach of the STS Movement (Santos, 1999; Hodson, 2003; Bonotto, 2006). The environmental issue is closely related to the conceptions and values built by our society, which support our actions involving Science, Technology and the Society, and, consequently, affect our relationship with the environment – the STSE relations.

Then, according to this perspective, to deal with EE we need to reflect on these relations so as not to reduce environmental problems to single out resource management and individual behavioural changes. This means a revolution in institutions, systems, lifestyles and values (Fien & Trainer, 1993), which is necessary if we really want to stand up for the environmental problems.

Since the work with conceptions must aim at reaching a deeper level of beliefs and values that support them, we turned to values education. We need to identify the values subjacent to a common world vision as well as to work with new proposals that can subsidize a new vision and practice by the society. Agreeing with Scott & Oulton (1998), values education is central to EE and it is explicitly necessary to explore these values in school.
A list of these values was identified according to the "Treaty on Environmental Education for Sustainable Societies and Global Responsibility" (Viezzer & Ovalles, 1994, p. 29). This document, directly prepared by civil society during the Earth Summit in 1992, may be regarded as a representation of its values, wishes and understandings. Through it, we can emphasize:

- valuing the life of all living beings (valuing biodiversity and the need for society to reassess its attitude towards all the other living beings on the planet);

- valuing cultural diversity, opening for conversations with other cultures and different forms of knowledge (reassessing the aggravating value placed on Science as superior knowledge and the one which has exclusive right to the truth);

- valuing a sustainable model of society, based on equitable sustainability and quality of life for everyone (reconsidering the direction of technology concerning its articulation with the current capitalist economic model, which has established growing needs for consumer goods, the ones which attain a niche of the population that has been growing smaller and smaller);

- valuing responsibility, solidarity, cooperation and dialogue, which make possible everyone's participation in building up a fair and balanced society, where one can participate in the decisions that affect everyone, a task no longer considered exclusive to specialists, scientists and governmental authorities.

Under this perspective, it is necessary to include in EE educative practices with those values in addition to tasks related to other contents, considering that we do not learn and teach values in the same way we learn and teach knowledge and abilities (Zabala 1998; Ercilla & Tejeda 2004).
However, in Brazil, besides the difficulties to treat EE in schools, we must add to this the non-familiarity of the teacher when dealing with the value content in education as a whole. In fact, the difficulties in focusing on value content and ethical questions involving science teaching and EE have been pointed out in the literature by different investigators around the world (Layton, 1986; Vercher, 1992; Ballantyne & Packer, 1996; Levinson, 2002; Oulton, Dillon & Grace, 2004).

Taking into account the re-emergence of values in Science Education, Corrigan, Dillon & Gunstone (2007) presented different authors who discuss the subject, pointing out this work's possibilities and limitations. When treating the implementation of a curriculum with such emphasis, several of them have called attention to the challenge that it represents to teachers (Hildebrand, 2007; Dillon & Reid, 2007; Ratcliffe, 2007), indicating an important issue to be included in teacher education programs and in investigations seeking to illuminate how to deal with this particular challenge.

THE RESEARCH

Considering this problem, in the last years, I have elaborated and developed teacher education programs that deal with this theme – EE and the work with values – investigating the teachers' learning, under a qualitative research approach (Bogdan & Biklen, 1998). Using a line of inquiry that is rich in descriptive data, focus on individuals' perspectives and interpretations of their world (Miles & Huberman, 1994), the investigation can show aspects of the process that could not be perceived by using a quantitative approach. The research results are concrete aspects that can be used to confront with others in similar contexts, encouraging other researches in the same direction.

I have already organized and carried out three teacher education programs that took place in a city in the countryside of São Paulo state, Brazil:

1- one in-service program in 2001, directed to eight primary-school teachers (7 to 10 year olds), who worked in a municipal school network;

2- one pre-service program in 2004 and 2005, directed to approximately one hundred twenty future science and biology teachers, students of a Biology University Course which prepare them to teach classes in middle and secondary schools (11 to 17 year-olds);

3- one in-service course in 2008, directed to six science and two language middle-school teachers, who worked in the state school network teaching middle classes (11 to 14 year olds).

In these three investigations, my goal was to investigate the teachers' learning in dealing with this topic (the environmental education and its value content), pointing out relevant aspects involved in the apprehension of the subject and its incorporation in their classes.

The data was collected from the different written activities I had handed out to the training teachers, from the teaching plans they had to prepare (during the meetings we had) and teach to their pupils, as well as from the researcher's notes I made after these classes. In the case of the 1st and 3rd programs, I interviewed the teachers in both programs and videotaped the meetings in the 3rd one. The same questions are brought up to the teachers involved in the semi-structured interviews to gather descriptive data in the subjects' own words.

Based on the data collected and after consecutive readings, I extracted the key points that are grouped into similar ideas. By this qualitative data analysis (Bogdan & Biklen, 2006) I could identify some aspects linked with the learning of value content in the environmental issue.

In this paper, I will focus on one group of these aspects, referring to the uncomfortable feelings and queries the teachers had, representing the challenges that they faced while trying to work with the change of the world's vision and values. Is the teachers' vision of science and scientists coherent with the changes that are indicated? How do they evaluate the technological products they themselves consume? How can they educate considering different values from those continuously showed by society? How can teachers educate in values if they themselves are not a good role model? Finally, how can they teach something that they found out has not been learned yet?

I observed these questions clearly emerging during the reflections on the relation between the environmental question and the capitalist and consumerist model of our society, the influence of science and technology in this process and the deep changing proposals of this model.

I will discuss these problems grouped under three closely related categories, presented as follows.

Difficulties on a personal level

The invitation to modify traditional practices, dealing with a changing of conceptions and values to construct a new model of society, is not an easy matter for anybody, including teachers. After some discussions, teachers showed to be insecure and doubtful in their accounts. This mainly occurred when they reflected upon the intensity of the necessary changes and how our daily actions – including the personal ones – are distant from those considered more appropriate, as we can see in the following reports:

The present-day activities showed how difficult it is to change. Is it possible? I saw that all these things are already part of our culture and they represent a habit acquired before our birth. I particularly adore technology, new things (...) (teacher V, 1st program).

Teacher AM – *Do you buy only what you need? I buy 100% of what I don't need!*
Teacher G - *I keep thinking: To what extent can I revert this situation?*
Teacher AM - *Ah, I think now I can't. I can't stop buying… I can't get rid of what I already had* (3th program).

The relationship between the environmental problems widely broadcast and the model of society of which we are (generally) representatives did not seem to be clear to some teachers. They reacted as though they were surprised by this "discovery," according to what one of the states of one of the teachers:

(...) we are always reminding our students of the nature preservation question, but we never associate it with our well-being, our daily routine (teacher L, 1st program).

Seeking to clarify the teachers' own values and conceptions, after an activity with puppets, we simulated a scientific meeting in which the emerged vision of science and scientists was discussed. One primary-school teacher identified, and very clearly expressed, the difficulty she felt modifying her vision of a scientist – an unusual and special human being:

I liked making the scientist puppet, but I confess that I am still bound to the conception of a scientist as someone distant from the actual world (...) (teacher R, 1st program).

These problems have already been identified by other investigations. As Ratcliffe (2007) and Hildebrand (2007) have indicated on referring to science teachers, the emphasis on values in the classroom requires that teachers reflect on their own values, which is not a comfortable process. Hildebrand (2007) also adds that the change required is related to the level of value-conflict that educators "can tolerate in their own values schema" (Hildebrand, 2007, p.58).

Concerning this question, I find important to bring here the reflections of Oulton, Dillon & Grace (2004) dealing with controversial issues. These authors indicated that to deal with controversial issues, it is necessary to explicitly take their nature into account. They emphasize, among other aspects, that "controversial issues cannot always be resolved by resorting to reason, logic or experiment" (p.412), because in the case of the moral dilemmas involved, "they have an affective component," so, "suggesting that a person's stance may be changed by rational argument is simplistic" (p.417).

Also considering science classes, Aikenhead (2006) pointed out that teachers' values, beliefs and ideologies must be in harmony before a teacher teaches subjects related to these aspects. But how can we reach this condition? Is it possible?

Oulton, Dillon & Grace (2004) suggest that controversial issues may be resolved as more information becomes available. I would add that to deal with these delicate feelings and discomfort we must be attentive and try to create in the classes a confidential space of reception, which is fundamental to build an atmosphere of confidence and freedom. That would facilitate the exposure of questions, conflicts and discomfort on the part of each teacher; thus constituting a group process that may help one another to clarify and work on their conflicts and visions, mutually supporting one another.

This aspect was shown by two teachers when I requested the group to point out aspects of the course they found relevant right after the end of the first teacher education program.

Teacher L-… for me, it was the discussion that always took place among the group. The fact that we were always exchanging ideas on the theme...
Teacher R-... a common [space].
Teacher L-... talking about our questions and afflictions.
Teacher R- I guess it was like this, then the question about affection would arise; because it grew really strong. Because it was like this: one supporting the other..." (1st program)

At the same time, it is important to remember that such space is crucial in the process of construction of (new) values we want to see implemented in society, of which teachers are part. When considering that, according to a Piagetian constructivist-interactivist model, values are built up from the projection of positive feelings an individual makes on objects, people and/or relationships (Araújo, 2001), there must be a warming atmosphere for teachers to both reevaluate their conflicts and be able to build up such values.

This is an aspect to be properly addressed in teacher education programs concerning EE, making it possible to handle the anxieties arising from the aim of favoring the intended changing process.

Difficulties considering the opposing influences brought by students Alongside the constraint when identifying the need – and difficulty – for them to change, many teachers showed a similar sensation when they thought about working together with the students:

We can not predict; it is difficult to put it into practice – sustainable development (...) This job is much too difficult. I frankly don't know how we teachers can bring such an advance in our students' lives (Teacher P, 1st program).

While working with her pupils, one of the middle-school teachers explained her difficulties and efforts tackling the consumerism aspect of the waste problem: according to her account, the pupils had a vision impregnated with the idea of only recycling things, and did not easily consider the question of reducing our consumerist attitudes, perhaps a hidden positioning in our capitalist and consumerist society.
One year after the 3rd program was concluded, she was interviewed; and this is the response she gave to this question:

(...) When I worked in the Project, I felt they [the students] *were reluctant, they didn't want to talk about the subject, because it is something that hurts! Because you saw all this question* [about consumerism] *that was dealt with in the text, the song, the movie… it touched, right? It touched*

because that's what it does! (...) and then, when you reach the point of 'I,' what 'I do,' what 'I am like,' [if] *I don't do the same, ah... so what? 'Not me, teacher, no way, you know! Do you think I'll stop buying candy?' So, there is a lot of talking, but when it comes to attitude, very few people are into it! That's a huge problematic issue* (Teacher E, 3rd program).

Dilon & Reid (2007) also showed, in a statement of a teacher investigated, her sadness about the behavior of the children they receive in an EE Centre, "so out of sorts with themselves and their planet" (p.87).

It is necessary to be clear about the difficulties and limitations of any educational activity, mainly when, in the case of EE, we are willing to foster changes in light of the present life style.It is also convenient to bring about reflection on the procedural character of education in these dispiriting moments. Such reflections I presented to the teachers in the 3rd program and, from this stimulus, they started to talk about several experiences they had, remembering situations in which they clearly realized the positive influence they had on several students.

So, when working with values, I consider that it is very important to recognize that the possible changes are neither easy nor fast (we cannot try to achieve total control and absolute success of learning). Additionally, as Hildebrand (2007) says, "We cannot easily 'test', in the conventional manner, or even 'assess', in a more authentic manner, whether or not our students have learned the values we intended in our curriculum statements "(p.46).
This must constantly be explained in teacher education programs, thus helping teachers to forecast their work possibilities more clearly.
This message, mentioned again and again in the teacher education programs analyzed here, due to the repetitive dispiriting moments, reappeared in Teacher E's account, when she was interviewed:

(...) it won't work either; for instance, walk towards a student and tell him that he cannot consume anymore, you know! There's no way to do that (...) I guess [the consumerism question] *must be constantly discussed; it is not in a one-month project that you can* [solve] *that, you know. (...) You've got to keep trying. Who knows? One day, for instance, you have forty* [students in a classroom], *if one or two there have a different idea, or at least, little by little, pay more attention to this consumerism question, to what society requires from each one of us, I guess it's a beginning!*
However, so that it can be a work, to get good results, it would have to be a goal of the school, as well as of everyone in that school (Teacher E, 3rd program).

From personal to pedagogical difficulties in teaching
Accompanying the referred difficulties, I could once again note the uncomfortable feelings and statements of the teachers when facing the task of teaching their pupils about the EE proposals. Several teachers pointed out to the question of not living according to the values they bring to class, not seeing themselves as role models regarding the pretended values, which would make their action difficult:

(...) the student can see it when you're talking about something you believe in or when you're simply talking about it (...) if you talk about it, they question you; they can realize when you're telling the truth or if it's something like, "Let's say we cannot consume." And then I show off my last-generation cell phone; they're very critical of it (Teacher G, 3rd program).

This concern has a reason for being. It is widely accepted that one of the ways of values education is through the real example we give. Puig (1998) regards the role model as one of the ways from which value guidelines – principles that rule a social group's ways of life – are expressed. The models "show the possibility of values, suggest concrete ways of life that both express and initiate processes of encouragement, adoption and invention of ways of living and being." (p.202)

Thus, how can we deal with this impasse: teach about something we haven't (yet) experienced/learned? Assuming that the teacher also places him/herself in the position of learning in light of this situation, the clarity that working on values is typically a collective, long-term task may lead the teacher towards a less dispiriting posture, both in relation to him/herself and in front of the students.

Again, I realized that most of those teacher's questions were connected with a vision that changing is not a continuous process, being expected an immediate change, i.e. there are inadequate visions and practices, on the one hand; practices contemplated, on the other hand, and people should simply go from one side to another quickly and completely.

This reflection was introduced and discussed in the teacher education programs, and then reintroduced by teachers G and E when they were interviewed:

(...) *then, I guess we think it over and bring it into the classroom, and start to reflect, you know* (...) *and that happens here in the program; sometimes you pick up something you were going to throw into the garbage and say, 'how can I throw it away if I am telling my students not to, you know? I guess it was very productive* (Teacher G, 3rd program)

(...) *I haven't changed completely; no one does, right? But I started to see some things that I didn't before and I even... umm… started to police myself about certain things about consumerism that I didn't do before. It is difficult for you to change, though. There is a whole system involved. It's not because it's difficult to change that you won't change, you know!* (Teacher E, 3rd program)

Besides this question related to working with the students, I highlight another difficulty that has arisen in these analyzed experiences, in terms of the insecurity it caused to the teachers. Several of them clearly exposed their fears of having an authoritarian attitude towards the value content of the subjects they were teaching.

Three teachers participating in the 1st program expressed such concern when they were questioned, before the course started, about the ways in which they developed the values education task.

In the second program, this question also represented a difficult matter to the future teachers. After the first presentations about values education, practically all students pointed out in a written assignment that it is such a delicate theme and that it should not be imposed. After several classes, one of them put forward:

Values education is a difficult task, because sometimes we do what we cannot. The education that I received has imposed opinions and then it is not easy for me to do it differently (F.A.K, 2nd program).

This dilemma concerns the problem of universality *versus* relativity of values, one of the greatest discussions involving the values education theme, which ends up causing conflicting situations for teachers when it comes to the way they behave in their classes. The fear of indoctrinating and, consequently, trying to be neutral, already described in the literature, sometimes proved to refrain teachers from working with values. As Scott & Oulton (1998) have already explained, "presenting pupils with a balanced view seems to be taken as fundamental to the pedagogy, but there are some dilemmas here" (p.219).

We consider that values education is the way to avoid extremist standpoints; so, when it comes to judging and choosing values, not everything is equally valid, a fact which must be pointed out (Puig, 1998). From this perspective, we can and must determine some valuable principles that may be turned into guidelines for judgement and human behavior, principles which can and should be introduced into the education process. That is the case when we work with environmental values, already listed in this paper, to which the teacher should be committed.

According to this positioning, Scott & Oulton (1998) discuss about the necessity and benefits of teachers to explicitly declare the environmental principles. Oulton, Dillon, & Grace (2004) encourage teachers “as much as possible to share their views with pupils and make clear the way in which they reach their own attitude towards an issue” (p.420).

Of course it is necessary to recognize that it is not an easy task. As Scoot & Oulton (1998) have already pointed out that “this is difficult enough when focused on relatively straightforward issues as litter or recycling, but impossibly complex when it comes to more abstract, large-scale and remote issues such as acidification or global warming” (p.219). The opposite difficulty has been presented in other investigations, in terms of leaving open questions to which a correct or more correct answer cannot be determined. Ratcliffe (2007), investigating two teachers in a project that emphasized the explicit work with the values dimension of science, pointed out the difficulties they had developing class discussions about the conduct and nature of science. The teachers tended to try to confirm the ‘right‘ answer or to avoid the discussions because there may be many valid answers, though the situation is seen as too complex to consider. It happened “as if they see engaging students’ overtly in considering evidence and making value judgments as a mine field of relativism where anything goes” (p.123).

Therefore, the question of the teacher’s neutral or committed behavior towards values presented in class requires great sensitivity and a good training from the teacher in order to avoid the prejudices that radical positioning can promote on both sides of this dilemma. Being attentive is really necessary “so that neutrality does not mean abandonment and that commitment is not turned into heteronomy” (Puig, 1998, p.234).

FINAL CONSIDERATIONS

All these challenges here presented are important issues to be considered in teacher education programs directed to EE. Fears, insecurities and dispiriting reveal the affective dimension that spans not only values content but both concept and skill-related contents of learning. However, generally the last two constitute the emphasis and interest of educational institutions, showing to be more tangible and liable for intervention, while the feelings dimension remain hidden. But when dealing with values content, it strongly emerges and shows us that it can not be disregarded.

Actually, it is not easy to deal with values and the feelings dimension they hold. In this paper, I tried to reflect on some possibilities of conveying it, with no intent on exhausting the subject, nor disregarding the need for offering information and discussing the conflicts, which has already been indicated in the literature. I am only sure of the fact that this dimension cannot simply be ignored, mainly when dealing with building up values, a process in which affection plays an important role (Bonotto, 2008). I thus agree with Gayford & Dillon (1995), who have already pointed out that a simple concern about knowledge and conceptual understandings in teacher education programs denies the role of emotions, and the wider aspects of "knowing" that should involve considering it too.

To conclude, EE implies a challenge to change world's visions, values and practices, a learning process that involves all citizens of the society, including teachers. This must be considered and carefully exposed to them, helping the teachers to deal with their feelings and expectations. But, if we are to point out our incoherencies, which can bring us discouragement, it is necessary to point out the small achievements, step by step, which show us that it is neither *easy* nor *fast* to construct a new world, but it is *possible*.

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ENTERTAINING SCIENCE SUMMER SCHOOL ACTIVITIES FOR PRIMARY PUPILS

Esma Buluş Kirikkaya
University of Kocaeli, Faculty of Education
Primary School Education
bulus@kocaeli.edu.tr

Gülşah Bali
University of Kocaeli, Natural Sciences Institute
gulsahbali@hotmail.com

Gurbet Vurkaya
University of Kocaeli, Natural Sciences Institute
gurbetvurkaya@hotmail.com

Şebnem Işeri
University of Kocaeli, Natural Sciences Institute
sbnmiseri@hotmail.com

Esra Bozkurt
University of Kocaeli, Natural Sciences Institute
esrabozkurtxxx@hotmail.com

ABSTRACT

For the children who are our future; by offering an environment to discover happiness and excitement of experimentation, to improve and develop their verbal, analytical and scientific thinking skills also science curiosity and interest; ensure to children future continuity and communication with science and technology are among the targets of science and community projects. Therefore at this study; "Entertaining Science Summer School Supported by TÜBİTAK" was coordinated for primary pupils who are considered will be most affected from the process, which consist of organized different methods and techniques and sports and arts activities that may be compatible with them. Primary school students who are studying at Kocaeli province constituted the universe of this study. The sample of this study was constituted by 50 students who want to attend school volunteers from among in the fifth grade science students was determined by simple coincidental sampling. In this study; to benefit students from science school and to evaluate interaction of students have been admitted to views of students and their parents. Science Summer School students expressed their opinion shape of they benefited from science school and it had a very positive impact on them and they wanted to spend more time there. Students' parents expressed their opinion shape of their children participated the activities enthusiastically and they like the activities.

Keywords: *Science Summer School, primary pupils, 5. Grade.*

INTRODUCTION

Children with the necessary facilities to deal with science from an early age, developed feelings of excitement and demand in science is seen (Crowther, Norman ve Lederman,2005). Children who actively exploring the environment use their senses to make observations, to order these observations, they are doing and make inferences from these observations. Thus, they develop feelings of curiosity, they talk to their friends and adults, create questions in their mind and they record by making them as pictures, modelling, writing or other activities (Akman, Üstün ve Güler, 2003). Children's natural desire to explore has an important role in the development of scientific awareness at them, and this feeling is the most important resource will benefit throughout their all education life. Ormerod and Duckworth's (1975) literature study stated that 8-13/14 years are critical child's ages to improve behaviours about science by emphasizes the importance of childhood years. Hodson and Freeman (1983), stated to create the behaviour of modern science and scientific image which are offered to children (under 12) and identify their elections have great importance.

Not only schools and teachers throughout all components of society must work for revealed or ensuring continuity sense of this interest and curiosity which starting in the early years in science. These days science education are among the topics no longer primarily interested in the world of science academies. Particularly after the 2000s academies of science in many countries, trying to add education programs as a voluntary activity at preschool and school children to develop their interest in science and science education. Informal environments, such as summer camps, create enabling learning environments may complete the knowledge and skills learned in the schools, research and experimentation. Individuals will be realized that they have to think comprehensive and interrogator for reach systematic information in as such environments (Noel-Storr, 2004). Leon Lederman is the the Nobel physicist who makes the issue widespread throughout the world first. Starting at low level of the economic environment around Chicago, a volunteering-based science education program was implemented successfully.

While science summer camps provide learning environment be more engaging and motivating students, create informal learning environments for students. Camp programs are generally short although intense. When consider the total hours of one-week camp program is equivalent to almost one-two months education at school. This type of science camp is a very good option for environmental learning (Kılıç ve Yardımcı, 2009).

Metin ve Kılıç (2009) ; practiced TÜBİTAK funded science summer school projects in 2008 called "Science, Nature and Children, Three in One Summer Science Camp" and while they searching during proocess, they noted science camp helps students understand the nature of science and explain how scientific knowledge changes.

Purpose and Importance:

Children’s natural desire to explore has an important role in the development of scientific awareness at them, and this feeling is the most important resource will benefit throughout their all education life. Learning science for children will help recognize the world and find solutions to various problems they faced. While science education given especially to younger children, should be guided them; must be provided to learn with having fun and exploring; should be minimized concerns and fears (Cho, 2003; Wilson, 2004). The training in this project includes science and technology activities and music and sports activities which can eliminate children’ fears and concerns that may have acquired in science and math courses, present fun face of science and designed different methods and techniques. Also within the scope of this project uncover and develop students' abilities and interest in science is targeted.

In this research, it is tried answer three questions for pupils’ to take the advantage of science schools and interaction of it.

1: What are the thoughts of pupils about the activities in Summer Science School?

2: What are their thoughts of pupils about the the going on impact of Summer Science School?

3: What are the thoughts of pupils' parents about the changes on students during the activities?

METHOD

A pilot study was implemented with the support of Kocaeli University Research Fund for identify disruptions or problems which may arise during the realization of this project in the summer of 2008. Pilot study made great impact in the province and has been a mediator to emerge a very intense demand. During the pilot study, sample was selected from 5th and 6th grade students. For each grade, 20 students selected through the 5th and 6th grade students whose applications were accepted. Amount of the sample was appropriate for carrying out the study and a program was prepared for two weeks, a week for each group. But, it was decided 5th grade students to be the target group, because of coming into demand especially from the 5th grade and according to observations which were made during the pilot study. This occasion, constituted an important step for the realization of the project.

In this study, the subject projects have been supported by TÜBİTAK. The universe of this study is constituted by primary school students who are studying at Kocaeli province. The sample of this study was constituted by 50 students who want to attend school voluntarily among the fifth grade students who were determined by simple randomly sampling method. The science summer school consist of activities which are organized with different methods and techniques for ensure students benefit the highest level from science school and sports and arts activities that may be compatible with them

In this study the ideas of pupils and their parents were gathered to evaluate the benefits and interactions of science schools. Three methods were used to get pupils ideas. First one was gained with the questionnaire which consists of open ended questions at the end of the activities to determine their ideas about Science Summer Schools.

Second was gained through their writings about their comments in flower class at the end of each day. Third one was gained through twenty students from their school after two months when the Project ended. Parents' ideas were determined from the interviews after all activities were done. The data of pupils and their parents were examined by descriptive analysis method.

FINDINGS

The activities in the concept of TUBITAK's Science Summer School in total 50 students attended and 25 of them from second group. However one of the students was quitted from the evaluation as he become ill. Therefore, there were 49 students in total. 18 of them were girls and 31 of them were boys.

Students present schools are learnt and it's determined that 25 pupils go on their education in 25 schools in the borders of Kocaeli. As their schools show differences and their environments are restricted, it is shown that research has reached the target mass coincidently. Attendees have expressed that 40 of them have never attended such as an activity while 9 of them have experienced before. They have attended science schools, Maths Olympics, various projects and science museum responds.

When we asked the reasons of attending or their expectations from the activities, 32 of the attendants have answered as learning, enjoying while 6 of them have responded they enjoy science and technology. 7 of them liked to spend their free time on experiments and 3 of them hope to find friends and learn something. Only one of them has come for preparation for The Exam of Identifying Students' Levels (SBS).

Pupils' General Ideas About Science Summer School

The data about pupils' responds to the questions if they like the activities or not, if they feel themselves lucky or not, the distinctions from the school are given in this part.

It was asked if they see themselves lucky and happy or not for attending the Science School. f=49 of them have expressed they feel lucky and happy; they have had a very good time here. None of them has given a negative respond to this question. This finding is a sign of reaching the project's target.

In Table 1, the responds of the question; "Are the activities in Science Summer School different from schools' activities? If it is, express what they are?" are given.

Table 1. Pupils' responds' frequencies for the question. "Is there any diffrence between the Science Summer School activities and school activities? If yes mention what they are?"

Pupils' ideas	**N**	**f**
Both lesson and enjoy	49	20
This is better	49	13
It's different. There are more experiments here.	49	10
School is more uneasy	49	1
We do similar things at school.	49	5

In science summer school for f=20 pupils the reason of the difference is both lesson and enjoy while for f=13 the activities are more enjoyable than schools' and for f=10 the reason of the difference is that there are more experiments here. For f=5 pupils similar activities are held in schools, and for f=1 they can behave more independently at summer school.

In Table 2, the frequency of the responds to the question "Do you suggest science summer school to your friends? Why? Why not?"

Table 2. Pupils' responds' frequencies for above question.

Pupils' Ideas	**N**	**f**
Enjoyable, beneficial and lovely place	49	25
I suggest it is beneficial	49	15
Yes. They will be happy	49	8
I don't suggest. We are sad as it has finished.	49	1

f=25 of the pupils suggest as it is enjoyable, beneficial and full of love, f=15 say that they will suggest as it is beneficial. f=8 pupils say that they will suggest their friends as they want their friends to be happy, too.

Responds of the attendants of the question “What have made you the happiest at school? Make a list of them” are given in Table 3.

Table 3. The frequencies of responds to the question “What have made you the happiest at summer science school? Make a list of them”

Pupils’ Ideas	**N**	**f**
All	49	23
Sports activities	49	15
Laboratory	49	6
Space and black hole	49	2
Trip and observation	49	2
Drama	49	1

f=23 of pupils have expressed that they had a good time during all activities, f=15 of them in sports activities (swimming and skiing), f=2 of them while watching space and black holes documentaries and f=1 of them had a good time during drama activities.

Responds of the attendants for the question “Which activities did you like or are you interested in most? Explain why?” are given in Table 4.

Table 4. The frequencies of responds to the question “Which activities did you like or are you interested in most? ”

Pupils’ Ideas	**N**	**f**
All of then are attractive	49	22
Space and black hole	49	8
Laboratory, shampoo and perfume	49	7
Examining the living things	49	2
Forest activities	49	2
Electric activities	49	1
Experiments	49	1
Finding trees’ ages	49	1
Water trombone	49	1

f=22 of the pupils expressed that they liked space and black hole documentary, f=7 liked shampoo and cream activity in laboratory, f=4 of them liked sports activities, f=3 of them liked forest and examining living creatures and water trombone.

When their responds to the question “what would you like to see in science summer school? State please” are examined. f=32 of them have found the activities satisfying while f=8 of them wanted more sports activities. F=7 of them wanted more experiment and survey, while f=3 of them wanted more trip and observation.

The Findings About Their Comments in Flower Room

The pupils’ flower room comments about the activities at the end of the each day are presented with descriptive analysis method.

Comments of the first day

When their first day comments are evaluated, 47 of them told that they had a better day then they thought it to be while only two of them told they had not accustomed yet and so they had not enjoyed yet. Some of them expressed that they have experience in a laboratory for the first time so they were excited. In Table 5 the range of the given and liked activities’ frequencies are given.

Table 5. At the end of the first day, the frequency of their most concerning activities.

The most concerning activities in pupils’ comments.	N	f
Activity 1: Let’s do our own perfumes! Creating perfume with Water vapour with Distillation	49	24
Activity 2: Your wonders about light: How does the light move? How to make a kaleidoscope.	49	43
Activity 3: How to introduce sound? Let’s to water trombone!	49	40
Activity 4: Let’s do rhythm instrument, Let’s create rhythm!	49	38
Alternative activity 3.”Let’s write invisible writing!”	24	12

Pupils have expressed that they liked making the kaleidoscope and water trombone most and they learnt much from it; but they did not like perfume activity as they did not like its smell.

Data on the second day’s comments

At the end of the second day when their writings are examined, it has seen that f=49 (all) of them had a very good time and enjoyed their time much and they found the activities interesting. Most liked activities’ frequencies are given in the Table 6.

Table 6. Their most liked activities' frequencies for second day.

Pupils' most concerning activities	**N**	**F**
Activity 5: "Let's make a journey to the world of living things."	49	48
Activity 6: "Shampoo and cream production factory"	49	43
Activity 7: "Sports time; Let's swim and enjoy the moment."	49	46

When the Table 6 investigated, it has seen that f=48 of them liked the 5th activity most. It is seen that living things and nature still is among the most interesting topics for pupils.

Data on the comments of the third day

When the third day comments are examined it is found that for the f=46 students had a good time and they were really happy while f=2 of them had a moderate day and it would be better and for the f=1 the day was a bit boring.

Their most liked activities' frequencies are given in the Table 7.

Table 7. Their most liked activities' frequency ranges of the third day

Pupils' most concerning activities	N	f
Activity 8: "How to make our city's most famous dessert 'Pişmaniye' Let's go to work shop of it"	49	44
Activity 9: "Let's paint our cell and nucleus take a photo of it"	49	31
Activity 10: "Tree dating laboratory"	49	31
Activity 11: Let's do sun buttery"	49	40
Activity 12: "Let's visit to the archaeology ,the ethnography and the underwater museum ship"	49	46

Pupils' general ideas about the activities are positive; however they mostly talk about the visits to the museums. f=46 of them told that they had a good time while some of them expressed that they had been at a museum for the first time. After the visit to the museum, f=40 of the pupils expressed that they liked the activity of "let's do sun buttery". At the end of the day they told that they liked "let's paint our cell and nucleus and take a photo of it." and "tree dating laboratory" activity most.

Data on the comments of the forth day

When the day's comments are examined, f=48 of them expressed that they had a good time and they learnt many new things and they were very happy, while f=1 of them expressed that their expectations were not satisfied.

Their most liked activities' frequencies are given in the Table 8.

Table 8. Their most liked activities' frequency ranges of the third day

Pupils' most concerning activities	**N**	**f**
Activity 13: The Richter magnitude of an earthquake and Let's determine the amplitude	49	42
Activity 14: "How do robots work?"	49	39
Activity 15: "The documentary of black holes"	49	42
Activity 16: "Let's do ceramics about the global heating"	49	40
Activity 17: "We are learning skiing"	49	46

When we examined the forth day comments it is determined that almost all of them liked the activities. When we examined Table 8, the most liked activity is "we are learning skiing on the ice." with f=46 while f=40 of them liked "Let's do ceramic about the global heating". After these activities "the Richter magnitude of an earthquake and let's determine the amplitude" and the "documentary of black hole" activities are liked mostly. The least liked activity is "how do robots work?".

Data on the fifth day's comment.

When we examined the last day of the summer school, it is determined that f=49 of the pupils were so unhappy as the science summer school was over and they wanted come again and they had a really good time. Their most liked activities' frequencies are given in the Table 9.

Table 9. Their most liked activities' frequency ranges of the fifth day.

Pupils most concerning activities	N	f
Activity 18:"The journey of electricity charge"	49	33
Activity 19: "Drama: to protect environment."	49	32
Activity 20:"Poster competition: our creativity is online."	49	37
Activity *21:* *"*Let's plant tree.	49	40

Most of the pupils wrote positive comments about activities on the fifth day, and they expressed that they enjoyed in all activities. However, especially for f=40 of the students, "let's plant tree" activity is liked most.

When we look at the comments about all of the days, it can be said that the least mentioned activities are even talked much about themselves. This is a sign of reaching the targets.

Findings From the Interviews With Students Two Months After the School Had Finished

To determine ongoing effect of “science summer School for Primary Students”, interviews have been done at their schools. The analysis of these interviews is given below.

- “Did you talk about the activities in Science Summer School with your friends at school or street? With whom? How?” questions were asked.

When the responds were examined, they have expressed that they liked the activities and they also wanted to have such an experience. Some of the responds are like this;

Selin: “*Of course, I have talked about it with my teachers and friends from school or street. I have told some of the information when it is suitable or required.”*

İlker: “*I did. I have told them to my classmates. I have told them the activities; I have told that almost all activities were about science. I would like to join there again with my friends. I have told them sun buttery. It was very good*.”

Kubilay: “*I have talked about it with my schoolmates. I told that it was very good and we had a really good time. I want all of my classmates to attend this class*.”

Fatih: “*I have shared my experiences with my classmates. It attracted their attention, too. They told me that I had been very lucky*.”

Sıla: “*I did. I shared my experiences with my classmates. They understood that I enjoyed very much and they envied me*.”

- Secondly, “Have you told about the activities in Science Summer School with your teachers? Which were their departments? How? What are their reactions?” is asked.

When the responses are examined, it is seen that most of them have shared their experiences with teacher and they mostly have talked with their teacher of science and technology. With their science and technology teacher, they had talked about the experiments. Differently, they had shared their experiences with class and visual arts teacher about the poster competition. Some of the responses are given below.

Halit: “*My science and technology teacher was more interested about my experiences at summer school. As a reaction he said “well done” and “I am pleased that you attend it.*” Moreover, I have changed my school, in past there were not any laboratories at my school, but now there is. (It is really enjoyable.).”

İlker: “*I told about the sun buttery and other activities. They were pleased for my attending. They made us to prepare five-minute presentation about the Science Summer School.*”

Orhan: “*Yes. I told about the Science Summer School whenever it was the subject and I still talk about it, I have seen positive reactions*.”

- Thirdly, “Have attending Science Summer School changed your ideas about science and technology classes? If yes, how? ” is asked.

When their responses are examined, all of them changed their attitudes about science classes positively. From now on, they are not afraid it no longer, they have liked it more and they are more interested in it. Some of the responses are given below.

Kubilay: “*Of course! I liked science more*.”

Sıla: “*I didn’t like science classes before. I like it more now. It is more enjoyable now*.”

Halit: "*Maths and Science lessons are always my favourites, yet I have learnt that they are more enjoyable*."

İlker: "*Thanks to Science Summer School, I am not scared of it any longer and it is more enjoyable now."*

- Fourthly, "Has attending a Science Summer Class contributed your lessons at school? If yes, how?" is asked.

Almost all of the students have expressed that they have liked science more and they are not afraid of it any longer. Some of the responses are given below.

Oğul: "*Yes, it has contributed much. I can understand science lessons better. The first unit was about cell. I have learnt much about cell at Science Summer School*."

Mert: "*I liked science classes more. Thanks to Summer Science School. I raise my finger more during the lesson. Moreover, I got 100 from both first and second exams.* "

Fatih: "*This course contributed much to my school. I feel respect and I am grateful to all my teachers. It is absolutely effective. I support my teacher with my knowledge from summer school while my teacher teaches*."

Parents' Ideas

In this section the findings are given from the interviews with parents and their direct speeches are given with the semi structured interviews.

When we asked "How did you learn about Science Summer School?", They have learnt from teachers. Differently, some of them learnt from web sites, headmaster, newspapers, and from their friends in universities. Examples from their statements:

Mrs. Fatma: "*We have been following this project for two years. I have learnt from newspaper. I applied as soon as I saw it and waited for the respond*."

Mrs. Zeynep: *"Our headmaster sent message to us so we learnt it."*

The frequencies of responses to the question "What were your expectations before attending this school?" are given in Table 10.

Table 10. Parents' responds' frequencies to question "What were your expectations before attending this school?

Expectations about the project	f
As we did not have any pre knowledge we did not have expectations	5
Required activities for experiments and researches	3
Learn something new	2
Learning something about other occupations	2
Applications of the written programmes completely and well	1
Activities which will make them recognize their talents	1
Swimming activities As they are interested in swimming	1

When table 10 is examined, it is found that most of the parents do not have any expectations as they are not having any information about the activities. The expectations of the rest of the parents are experimental and researching activities and new information for the pupils, learning about different occupations, applications of the written programmes completely and well, activities which will make them recognize their talents and swimming activities.

The respond of Mr. Murat: "*My son is self conscious. I want this project for him to meet new friends and so he will see that he can achieve something*."

Mrs. Serap: "*I have not learnt ideas of my daughter but she always told that "I can learn something from this school and I can tell them to my friends. And she had such ideas*."

Mrs Ayşe: "*My son was pretty excited. He wants to be a scientist or chemist and even an astronaut. He wanted to learn something about these occupations*."

When we asked "Have your expectations been satisfied?" nearly all of them responded positively. They agreed that their expectations were satisfied.

Mr. Haydar: "*I want stress that our children are impressed much by the experiments. We are all satisfied.*"

Mrs. Ayşe: "*When we examined the programme we wanted all activities to be applied and you did it*."

Mrs. Sevda: *"My daughter said that she wished all our education system was like this.* This is a really important change. It satisfied her more than she waited. She learnt such things that she never expected before. Because there is everything in it. She is interested in experiments but also she likes art, drama, social activities. They learn through joy. It is amazing."

To the question "Did your children mention about the activities at home?" they all said yes.

The respond of Mrs. Buse; "She *told me every day. "We did this and that…" It was amazing. She wrote what she did all day*."

Mrs Aslı: "*When she came back home she always told what she had done all day. "We did experiments, shampoo" she was so pleased with the activities. She showed us what she did in the activities."*

Mr. Murat: "*He told us everything. He told how they caught insects in the forest. Of course we shared with him, too. He never told something negative*."

When we asked "Were they eager to get up early in the morning?" they told that their children had never been so eager to get p early, they came there eagerly.

The Mrs. Irem: "*She is so eager. She counted minutes, seconds. She does not want to be late. She came as eager as the first day*."

Mr Haydar: "*He was eager. Fatih had friends at summer schools with him, they were all eager. They are ready at seven thirty. Why? They liked it. Their other friends and teachers all liked as they want to come. We did not have any problem about it."*

Mrs. Buse: "*Absolutely, she woke up eagerly, and even she was so quick so as not to be late. They say you pay much attention, personal attention and they come eagerly."*

The responds' frequency to the question "Are there any observable changes on your children?" is given in Table 11

Table 11. Parents' responds' frequencies to question "Are there any observable changes on your children?"

Observable changes about children	f
They are more sure of themselves	8
They are more sharer and turn to science	4
She/he is more curious	1
She/He is more eager to go to university	1
He/She is more happy.	1

When we examined the Table 11, the main change is that they are more social and they feel surer of themselves. The respond of Mrs. Eda is:

"Of course there are changes. For example, she was self conscious. She could not speak with others. Now, she tells everything to the neighbours. She could not eat anything when foreigners come. But it is over."

The respond of Mrs. Nesrin is:

"*There are huge changes about my son. He was very silent. He is more active and talkative now."* The respond of Mrs Serap is:

"He is aware that such a project contributed much to him. He can see he is different from other boys around him. He feels better himself. He learnt the significance of education. He learnt the significance of learning through doing it. He felt the self reliance of awareness. He has a different self reliance now."

CONCLUSIONS AND IMPLICATIONS

It was determined that pupils have positive comments like they benefited from the activities and affected positively, they wanted the summer science school to be more longer and arranged again next year. Also, most of the pupils stated that activities increased their self confidence and they could do science experiments easier.

It is one of the results among the Kanpur's Pupils' Science Education Camp is that pupils' are more confident while doing an experiment (Verma, 2007). At the end of Bağcı Kılıç and his asistant's (2009) project "Three in One: Nature, Science and Children" with the help of TUBITAK, it is emphasized that science summer schools provide informal learning, this learning environment is motivating and such kind of science camps is a good choice of environmental earning. In this research children expressed their good feelings, also which is proving. this.
It is determined that pupils have found the summer schools' activities more different, enjoyable, amazing, and beneficial. the researches on the space literature have proved that these kind of projects provides larger horizons for reaching to education opportunities and to join pupils from different cultures (Demirel, 2006). Moreover, pupils ,thanks to these activities, find the opportunity to share their creativity with their friends, teachers and the other parts of the society and these activities provide positive effects on the pupils (Tezcan & Gülperçin 2008).
Moreover, result of activities during project, the curiosity and interest of the children are tried to be determined to science and environment. It is found that this attention have lasted two months after the project. the different researches proved that the learning sources other than formal learning make learning more productive. it is seen that the variety of the activities which pupils spend time with and rising their frequencies have made their talents which they learnt at school before have expanded (Gerber, Cavallo & Marek, 2001; hannu, 1993) The parents of the pupils have expressed that pupils came to school eagerly, they have shared their experiences at home after school every day, they wanted to have a longer summer school and they thought it would be boring but they did not.
These suggestions can be put owing to the research results.

To improve pupils' curiosity and attention to science, to improve their reactions with their environment and to gain a positive view towards school, we can use science schools.

Pupils who attended the project can be selected for a science club by science and technology teachers and they can share the activities of the project.

Also it isn't the aim of this project that pupils reflect the knowledge they learned from project to their science and technology course. It was supposed them to develop positive attitudes towards science. And these positive variations will cause directly pupils to like and interested in this course more.

The projects' activities can be used by teachers;

To universalize these Science and Society Projects, academicians and teachers can lecture in-service education.

To universalize Science and Society Projects, a cooperation can be node between primary schools and universities.

Teachers can be supported for preparing projects like this in their schools. So much more pupils can benefit from summer science schools.

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REACHING FOR THE STARS: IMPROVING EPISTEMOLOGICAL ACCESS THROUGH UNDERSTANDING STUDENT VALUES

Ann Cameron

Science Teaching and Learning Centre /

University of the Witwatersrand

ann.cameron@wits.ac.za

ABSTRACT

Science as a way of knowing and doing is powerfully evident in modern life. The knowledge and expertise associated with it is consequently sought after to promote socio-economic development, even in situations where it may cause conflict with indigenous socio-cultural beliefs and the values associated with them. Drawing on research that investigated the impact of worldview on learning in basic astronomy, this paper considers the relationship between science education and human values in South Africa. It raises the issue of epistemological access in situations of cognitive conflict and suggests that cultural border crossing into science requires an open attitude on the part of science teachers, not just on the part of students. In South Africa the demographic composition indicates a predominantly religious and strongly multicultural population, with the fastest growing churches being African Independent Churches which follow a synthesis of African traditional religions and fundamentalist Christianity. In this context, the unmediated presentation of scientific theories which conflict with socio-cultural beliefs presents a complex set of moral problems which are linked to the effective teaching and learning of science.

Keywords: *Astronomy; cognitive conflict; epistemological access; student values; lecturer attitudes.*

INTRODUCTION

'Knowing' is closely linked to culture. It shapes how people live, it permeates their identity, and it determines how they will respond to new information. In South Africa, 'knowing' is associated with an individual's socio-cultural and economic environment, which may include language, tribal affiliation, schooling, levels of urbanization and economic class. South Africa is well known for its diversity, which is normally associated with race and culture. Yet onto this diversity, as far as science education is concerned, is imposed a one-size-fits all curriculum, which despite falling under the democracy-inspired principle that the existence and presence of 'other ways of knowing' should be acknowledged and valued, continues to follow the standard account of science.

Many of the teaching and learning difficulties associated with science are linked to problems such as lack of resources, poor pedagogic content knowledge on the part of teachers, and poor grounding on the part of students. However, some of these problems are associated with cognitive conflict, which is the result of conflicting accounts of 'truth'. The most commonly known context for this type of conflict is Darwinian evolution versus *ex-nihilo* creation, but similar conflicts are found in Earth Science, Paleontology and Physics. Big Bang theory, Solar Nebula theory and the concept of geological time, for example, are alien to students whose worldview has been shaped by African traditional beliefs and imported global religions.

While there has been considerable erosion of cultural beliefs and practices, accompanied by the adoption of 'western' lifestyles, African ontology is religious, with Africans described as being 'notoriously religious' (Mbiti, 1969, 1989).For the many South African people who view themselves as Christian (i.e. 80% of the population (Hendricks and Erasmus, 2005)), the unmediated presentation of the standard account of science can result in skepticism towards science, or even the wholesale rejection of science. Alternatively, it can lead to skepticism or rejection of their previously held ideas. The latter can have serious implications for students as far as their socio-cultural values are concerned, especially in relation to their home life and cultural community.

While the science education community is increasingly becoming aware that the teaching of science is not value free, science teachers generally, but especially those in the higher education sector, appear to be unaware of the need to engage students to create appropriate conditions for epistemological access. In the interests of improving learning without alienating students from their cultural or traditional values, it is critical in South Africa that science educators honour and respect such beliefs and values, even if they don't hold them to be true themselves.

SCIENCE EDUCATION IN SOUTH AFRICA

A history of inequality

2010 marks the 20th anniversary of Nelson Mandela's release from prison – a momentous year in South Africa's history as it heralded the beginning of a new political dispensation. In the two decades that have elapsed since then, education has undergone massive reform, primarily to address the inequities of apartheid. The single most important purpose of post-apartheid education in South Africa was the de-racialisation of the system. A news feature in *Nature* (Cherry, 2010, 727) highlights the fact that these reform measures were intended to "unleash a pool of talented students who had been denied opportunities under apartheid". However it is clear that most of these hopes have remained unrealized: over the past seven years, matric pass rates have declined by more than 10%, from 73.3% to 60.6% (Equal Education, 2010). In relation to educational inequities, an even more worrying trend exists: in 2008, for example, 99.3% of white learners passed their matric exams, with 68.7% attaining university level entrance passes. For black learners, the pass rate was 56.6% and 13.4% respectively. Indigenous black Africans make up 80% of the population, but in 2006, for example, only 12% of students registered in tertiary institutions were from this demographic group. The graduation rate for higher education is, at 15%, one of the lowest in the world, with the number of white graduates being more than double the number of black graduates (Letseka and Maile, 2008).The article in Nature points out that "since 1994, the government has in theory been committed to ensuring that 'blacks' (a generic term it uses to mean all people not classified as white under apartheid) have had improved access to higher education and research, but this has turned out to be difficult to achieve, particularly in science" (Cherry, 2010, 728). In this article, this is ascribed to the fact that "many black schools in the apartheid era did not offer mathematics and physical science as subjects, initially as a point of policy, and latterly on account of a teacher shortage" (Ibid.).

While these statements are true, they do not address the issue of epistemological access (Morrow, 2009), which lies at the heart of the argument presented here: science, as it is taught and examined at school and in higher education in South Africa, is a western product. Its power preserves it from needing to adjust to fit the context. In this case the context refers to South African students: they are expected to conform to the discipline and failures are ascribed to a lack of ability or aptitude on their part to adjust. The statistics given above speak of the scale of this lack of adjustment, and highlight the need for a different perspective to explain the lack of success in science, especially in relation to black African students.

The problem of epistemological access

Morrow (2009, 78) describes epistemological access as "learning how to become a successful participant in an academic practice". He distinguishes it from formal access, which describes the criteria that need to be filled in order to be accepted into an institution, for example attaining sufficiently good grades at school. Epistemological access, he says, is dependent on the student trying to learn, but in the same way that a coach and high quality equipment can help someone to become a successful athlete, 'it is the athlete who needs to do the running' (*Ibid*.).

In the context of science in higher education in South Africa, what does such epistemological access involve? To answer this question, we need to consider the epistemic values of the students in relation to the epistemic values of science. To do this, we will first consider the development of the new national curriculum and the values it has tried to introduce to honour and confirm all of South Africa's people. This will be followed by a consideration of the history of science in South Africa and the values associated with it, and how these may be impacting on the epistemological access of students. Evidence to support the need for awareness of epistemic values to facilitate epistemological access will then be given from a case study in basic astronomy.

The development of the new curriculum

The standard account of science is universalist: it opposes the existence, for example, of Aboriginal science or African science. However, research in science education, in the context of multicultural classrooms, has led to the well known concept of cultural border crossing (Aikenhead, 1996), which draws on the concept of worldview and argues that all knowledge is human construct and consequently there is no absolute 'Truth'. This relativist view advocates that science teachers should act as 'culture brokers' to help their students effect the border crossings required between their life world and the world of science. Research using this perspective as a framework has shown that the greater the dissonance between the student's life world and that of science, the greater will be their difficulty in learning science (Costa, 1995). As far as South Africa is concerned, it has been made clear that ontological and epistemological differences between African and western ways of knowing have serious implications for Africans in earning science (Jegede, 1997). Research studies in South Africa have confirmed that the lifeworlds and epistemologies of many black African students do not serve as an appropriate foundation for the construction of scientific concepts (Fakudze and Ogunniyi, 2003). Abimbola (1977) has even recorded that African children view science as a "pack of lies". Such views should not, incidentally, be conflated with notions of disadvantage or misconceptions. They are reflective of a knowledge system, i.e. a particular way of seeing and interpreting the world.

At the heart of the new National Curriculum, created and implemented in the years following 1994, is the constructivist notion of the importance of prior learning. South Africa's population, which currently comprises 80% black, 9% white, 9% mixed race and 2% Indian (SAIRR, 2010), is made up of a vast diversity of cultures, evidenced by the fact that South Africa has 11 official languages. Underlying this cultural diversity is a wealth of different 'ways of knowing', underpinned by cultural artefacts such as language, customs and belief systems. In conceptualizing the new curriculum, the need to recognize and ascribe value to these ways of knowing led to the inclusion 'of the need to acknowledge, recognise and value' these many different ways of knowing, as one of nine principles on which the new curriculum was developed (Department of Education, 2003). This principle is especially important and challenging in the science curriculum, which is made up of the standard western account of the physical world and reflects the dualism that characterizes western science at the level that it is presented at schools.

The new South African curriculum is special in that firstly, it recognizes the existence of Indigenous Knowledge Systems (IKS) and secondly, it requires, in the spirit of redress and equity, that these should be acknowledged and valued in the classroom. The transference from principle to application in the classroom is fraught with difficulty, however, especially for science teachers. One of the main problems arises from the fact that no conceptual guidance is given to teachers regarding how they should introduce or include indigenous knowledge in their teaching (Gundry and Cameron, 2008). The most unproblematic way to include IKS is to 'find' science in cultural practices. For example, the recognition of science (in this case cloud seeding) in the traditional practice of burning of tracts of natural land 'to create smoke to call the rain clouds' at the end of the dry season in the Lowveld areas of Mpumalanga (famous as the home of the Kruger National Park, and site of huge tracts of land being burned by local people to create grazing for their cattle) is exciting for those who seek relevance for African students in an otherwise western account of science. However, while the inclusion of such examples has been shown to stimulate interest in science (Manzini, 2000), they tend to be treated as curiosities or as subsidiary to the enterprise of 'real' science. In contrast to this, intractable problems arise when the knowledge associated with IKS is challenging from an epistemological point of view. Darwinian evolution, for example, which was formally included for the first time in the secondary school curriculum in 2008, is challenging for many teachers and learners. African traditional creation beliefs are varied but invariably involve a creator, and for those who have embraced Christianity, the notion of a created earth supports a fundamentally religious epistemology. The dualism of western science, where the physical is clearly separated from (and sometimes scorns) the metaphysical, does not fit comfortably with African philosophy: for the African, "to be is to be religious in a religious universe" (Mbiti, 1969, 256).

The development of science in South Africa

The development of science as an enterprise in South Africa provides a fruitful view of the philosophical exclusivity and universalist perspective that tends to be associated with science in higher education in this country. The fact that science was brought by European colonists and was predominantly a colonial pursuit may account for what Dubow (1995) has termed 'intellectual racism', or in the context of science, 'scientific racism'. Dubow, a historian who has studied the history of science and apartheid, suggests that scientific racism

> "initially arose out of the post-war anti-racist consensus which utilized the findings of modern population genetics to declare that 'race' was a biological 'myth' whose meaning was socially constructed rather than intrinsic. Increasingly framed as a social issue, the problem of racism came to be sloughed off from the concerns of traditional science and was absorbed instead into the domain of social science where it took shape as the study of 'race relations'" (Dubow,1995, 3).

Science was thus released from relativism, with science lecturers able to pursue their research and their teaching without having to consider issues such as the impact of worldview on teaching and learning in their discipline. Dubow highlights the sense of unawareness that accompanies much teaching in higher education by pointing out that "so much of popular racism exists as a matter of unstated assumptions and unthinking responses; it often has more to do with the *absence* than the *presence* of considered thought" (Ibid., 7). For scientist and science lecturers who are required to teach and perform research in their own field of study, work expectations and pressures and the relative value of teaching versus research in most South African universities precludes engagement with the messiness of educational research in science faculties. Science lecturers consequently attend to issues of curriculum and content rather than to theories of learning. Poor pass rates are more easily ascribed to a lack of suitable preparation at school, or inappropriate admission criteria, than to problems caused by differing worldviews and inappropriate prior knowledge.

However, science education research in multiculturalism points out the need to acknowledge the existence of other worldviews in multicultural classrooms and the benefits to recognizing the need for culture brokering. But cultural border crossing is not limited to the customs and social practices associated with IKS,. It has also been associated specifically with religious beliefs (as shown, for example, by Jackson, Doster, Meadows and Wood (1995), Roth and Alexander (1997), and Shipman, Brickhouse, Dagher and Letts (2002)). Liwane (2010) notes that “African people are collectively united by their religious experience. It is entrenched and pervasive in virtually all aspects of their lives on a daily basis”. In South Africa, religious belief systems are made additionally complex through the synthesis of African Traditional Religious beliefs being interwoven with the belief systems of imported religions, notably Christianity (Cameron, 2007). The strongest of African values derive from this deep religious base and the associated concept of ‘ubuntu’, the cardinal belief of which is “I am human because you are human”. From these issue all the fundamental values of an African worldview: group solidarity, conformity, compassion, respect, human dignity and collective unity (*Ibid*.). Cultural practices such as those that fall under the hold-all ‘IKS’ form one aspect that shapes an African worldview. But the values that are associated with an African worldview are tied to a religious epistemology.

The history of the development of western science is also a history of the split between science and religion, and this is embodied, in the context of higher education, in the separation into faculties which are distinct and separate, i.e. Humanities and Sciences. Science education straddles the two, but most lecturers in ‘pure science’ have not been exposed to the challenges of educational research and consequently are unaware of the potential clash between the students’ epistemic values and the values of science. While the curriculum battles that have been fought in the United States of America are well known, very little has been published in this area in South Africa. Periodically, research is reported in some of the prime international science education journals, yet few discipline specialists, i.e. the science lecturers in higher education, are interested in this literature.

In South Africa, where the majority of the population is Christian, and the fastest growing Churches are the African Independent Churches which practice a synthesis of mainly Old Testament theology and African Traditional Religion, the impact of worldview on learning in science cannot be underestimated.

A PhD research study on learning in basic astronomy in South Africa (Cameron, 2007) provides evidence of the necessity for lecturer awareness of students’ worldviews and their epistemic values in order to facilitate learning. Such awareness enables student participation in academic practice and facilitates the epistemological access which, it is suggested here, is vital to improving success in science teaching and learning.

A CASE STUDY: EPISTEMOLOGICAL ACCESS IN BASIC ASTRONOMY

Geography and Earth Science students at a large urban university in South Africa are required, as part of their first year curriculum, to take a course in basic astronomy to provide a foundation for later courses in Geology or Physical Geography. Since matric Geography is not a requirement for entry into degrees in Geology and Geography, ‘The Earth in Space’ course was devised to ensure that all students completing their first year had the appropriate background knowledge to progress further in their studies. Research over a period of four years into the poor pass rates experienced in this course, but notably in relation to black African students, revealed that students’ epistemic values created barriers to learning regarding particular aspects of the course.

Epistemic values grounded in culture and religion

The findings of this study indicated that students had a weak understanding of concepts such as rotation and revolution. This is not unusual as far as learning in basic astronomy is concerned: a recent review of astronomy education research (Lelliott and Rollnick, in press) shows it has been well established that all over the world, the counterintuitive and abstract nature of the mental models needed to explain these phenomena are difficult to construct. However, it was also shown that for many students some of the theories, notably the Solar Nebula theory which explains the structure and formation of the solar system, and the Big Bang theory, which explains the structure and formation of the universe, were challenging to their beliefs regarding the earth and their experience of it.

The most common traditional belief that emerged from the research held that stars were the 'eyes of the ancestors', who at night watched over their kin and protected them. Interviews with the students revealed that they generally accepted such beliefs to be myths, and were willing - in their context as university students - to replace them with scientific explanations, which were seen as credible and scientifically sound. However, for those students who also saw these theories as undermining of their religious beliefs, the cognitive reaction was frequently one of conflict and rejection. One of the most significant findings in this study was that half the students in the sample (49.6%) admitted to having difficulties in relation to the science/religion debate that was raised by the course. A typical comment was: 'I still don't believe the hypothesis that the solar system formed from matter that accreted together because I think God is the creator of the world and everything that is. Everything we learnt except the climate part was controversial and I don't believe it'. Interviews following a classroom questionnaire suggested that this figure was conservative: when given the opportunity to speak about their reactions during interviews, the students were far more emphatic about their distress.

The issue for these students was that the unmediated teaching of science not only left them feeling overwhelmed - as in "I used to believe the explanation given in the Bible, but now 'Earth in Space' has left me with a big task to do" . The problem was that the 'task' carried risk and consequences for their epistemic values. For students trying to make the learning their own, the task involved a difficult choice: to remain true to their previous ideas, as in: "Science cannot answer everything, so some of the things we can just conclude as: God made it this way and that's it", or reject them and supplant them with science: "I always thought that God created everything but now I find it hard to believe, because the Big Bang theory is understandable". Research in developed countries, notably the United States, has shown a similar spectrum of reaction by students to ideas that challenge their beliefs (for example Roth and Alexander, 1997). In the case of South Africa, however, the conflict is not just related to personal ideas: the rejection of previously held ideas is profoundly consequential in relation to deeply held values related to community and identity: as pointed out by Liwane (2010), group solidarity, conformity and collective unity are hallmarks of ubuntu. Students find themselves caught between two worlds, as indicated by a student describing his concerns about paleontology and the anticipated reaction of community and family: '…they have this belief in African tradition. When they look at the sky, they don't see a scientific thing – the stars are the ancestors looking down on them… (but) paleontology – that's the worst part! 'Cos paleontology is like digging up bones and stuff like that and for them it's like an insult to their ancestors! They believe… how can you dig up someone who is laid to rest, and who is watching all on you? So when you tell them about fossils and stuff like that… they really… they don't want to go there. They think no! no! no! the ancestors are going to be angry at us'.

On the one hand, then, students run the risk, in rejecting the ideas of family and community, of isolation and rejection, as in: 'When I am at home in the rural areas, I believe that all the traditional things work, because I do not want to be ostracized. Because, now, they say…'I believe I am white!'… its very difficult when I go home. I don't – I mustn't – speak English, and that's very difficult because I've been speaking English so much (at university).' On the other hand, rejection of what they were being taught meant that learning was compromised and carried the very real risk of failure. The legacy of pain of 'other ways of knowing' in Africa being considered inferior to western ideas, especially regarding science, and their fear of failure, was evident in the comment: “I know that we don’t fail because we are foolish, but because we get confused with the kind of information we have in our minds”. This is also clearly demonstrated in what was rather a laboured explanation: ‘…they try hard, they go to the library and pick up ‘heavy’ books for a simple explanation for how a star is born. You just have to get it, digest it and understand it. That’s it. There’s nothing hard about that. And then they think – no. Culture just closes them – but then again the person has a right to do whatever they want with their mind. And that’s how they fail to answer the questions properly, and then you bring their grades down. So it’s not entirely that they are lazy or stuff like that… they do try… it’s just that they don’t understand… they just can’t catch that idea.’

Border crossing and epistemological access

The findings indicated that the students who managed to find a way to deal with their conflicting beliefs were the most likely to succeed in the course, but they were few in number. Most experienced what is termed a ‘hazardous border crossing’ (Aikenhead, 1996), indicating that their chance of success was compromised. Comments that illustrate the cognitive conflict experienced included: “To me, a lot of the things in the course sounds very unreal. As a result I have had conflicts with previous and new ideas. Most of the time, I personally favour my previous ideas”, and “…like me, I don’t know about Big Bang till I do Geology at university this year. For people who are not doing Geology, when I try to tell them about the theory they think I am joking or it’s a fairytale”.

The response to the findings of this study was that in subsequent courses, ‘the elephant in the room’ was made explicit: the introductory lecture focused on the notion of ‘other ways of knowing’ and the fact that in the new South African curriculum, these were to be acknowledged and valued. Multiculturalism and diversity were to be celebrated, with due recognition being given to the existence of different epistemic values. Students were invited to share in the scientific explanations but recognize that traditional and religious explanations had their own intrinsic value. Discussion on the nature of science and the value of other ways of knowing was encouraged. The simple and respectful acknowledgement of difficulties related to epistemic values, particularly regarding understanding and engaging with evolutionary theories set the tone for a much deeper engagement with science. As one student put it: “If you are prepared to come and ‘play’ in my world, I am prepared to come and ‘play’ in yours”.

Aikenhead’s theories of cultural border crossing in science and the need for teachers to act as ‘culture brokers’ (1996) is well known. Jegede’s theory of collateral learning, which describes how students compartmentalize their knowledge (1995) is also well known, especially in the science education literature. The science / religion debate literature is vast, and there is a growing literature on IKS in South Africa. The problem is that all these areas represent disciplinary silos, which exist separately from the disciplines of ‘hard science’ which form the courses that students take at university. In courses in the biological, physical and earth sciences, culture brokering would be appropriate in aspects of physics, paleontology, archeology and astronomy, and of course in biological evolution. Such ‘culture brokering’ or ‘bridge building’ (George, 1999) does not need to undermine the academic status of such, which are esteemed for their role in providing access for graduates into the global ‘academic lingua franca’ of knowledge. Rather, it is to facilitate epistemological access, to provide a ‘way in’ to an engagement with science. This is particularly pertinent in South Africa, which enjoys the global heritage status of ‘The Cradle of Humankind’. For students who would otherwise struggle in silence or isolation because they are too afraid to challenge, or because their culture of respect requires that ‘you do not challenge your elders and teachers’, efforts by lecturers to build epistemological bridges could make a substantial difference.

VALUING VALUES AS A WAY TO FORWARD LEARNING

Morrow has pointed out that in South Africa "we all carry the burden of a manifestly unjust past" and that "given our history of political exclusion and the strong need to expunge that history, redress must be high on our agenda in the years ahead" (Morrow, 2009, 70). The point being made is that this redress must include recognition, in the context of multicultural classrooms, of the reality of different worldviews and the epistemic values associated with them. Awareness of the necessity for respectful recognition and acknowledgement by lecturers of such differences could help students to resolve cognitive conflicts rooted in their values rather than in their academic ability. Instead of reacting defensively or retreating, students may then be encouraged to explicitly grapple with problems related to their values. However, it must also be noted that an increasing number of black students have become 'secularised' from their traditional culture. While the need for epistemological access is consequently not necessarily applicable to all students, the opportunity to learn about different cultural values and perspectives is still relevant in the context of South Africa's diversity.

In the higher education environment, which is so tied to the 'institutionalization and professionalization of knowledge in South Africa…and to the relationship of this process to developments overseas' (Dubow,1995, 11), it may take accusations of 'scientific racism' to alert lecturers to their need to become aware of issues related to worldview and epistemological access. The typical academic culture of 'sink or swim' is counterproductive and it makes sense to follow Liwane's suggestion, that "conceptual frameworks of strategy and ideas must try and make reference to the African religious and cultural experiences if effective transfer and adaptation are to take place" (Liwane, 2010). This does not mean that lecturers would compromise the science they teach. Rather, it means that in awareness, they would be paving the way for more students to gain access to science. In South Africa, the balance of costs, i.e. a shift in perspective for lecturers, against potential engagement rates for students, is such that we cannot afford to miss any opportunity which can lead to an increase in the number of graduates. 'Epistemological access' is a concept that allows for the 'Africanisation' of science without compromising the final 'product', i.e. science graduates who are able to cope with ambiguity and contending theories.

CONCLUSION

This study has shown that in the context of South Africa, traditional and religious beliefs create a double layer of objection to science that is in conflict with students' beliefs and values. The focus of this paper was to draw attention to the role of the lecturer in providing epistemological access by explicitly acknowledging the existence of multiple worldviews in situations of potential cognitive conflict.

In their own journeys to becoming scientists and teachers of science, university faculty may never have been challenged themselves in needing to come to terms with different ways of knowing. However, in a country such as South Africa, which is characterised by cultural diversity, the unmediated presentation of science as universal truth comes at a cost to a country that aspires to increase education levels and participation.

The concept of epistemological access is one that may be fruitfully employed in a situation where the need to grow the number of black graduates is critically urgent. The requirement is that 'hard scientists' shift their gaze from their own pursuit of truth to considerations that affect learning. In the interests of producing successful 'athletes' (to borrow the analogy used by Morrow) the 'coaching' provided by lecturers should involve the development of a respectful curiosity about the worldviews and epistemic values of their students. While ultimately the students need to do the running, the critical role that lecturers can play in their students' success - through actively facilitating epistemological access - should not be underestimated.

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PISA 2006 MAIN FINDINGS IN SLOVENIA AND SIMPSON'S PARADOX

Gašper Cankar

Educational Research Institute

gasper.cankar@guest.arnes.si

ABSTRACT

Programme for international student assessment (PISA) is a well known OECD global assessment of 15-year-olds in key subject areas that runs in three year cycles and its results usually gain high coverage by experts and media alike with main findings published in newspapers and other media. Author presents main findings of PISA 2006 study for Slovenia, where data shows the classic example of reversed effects often referred in statistical literature also as Simpson's paradox. This happens when results from groups suggest opposite conclusions than those made from results on combined groups. Seemingly easy question of »who performed better: boys or girls?« can have a very ambiguous answer.

Causes of paradox in specific case are explored and implications for interpretation of findings are discussed. Since it is likely that conditions leading to Simpson's paradox in context of Slovenian PISA 2006 results will remain constant in near future this finding should be kept in mind when the results from PISA 2009 will be available for interpretation at the end of 2010.

Keywords: *PISA, Simpson's paradox, gender differences.*

PISA 2006

There is growing awareness about importance of following achievement of students all over the world. International studies such as TIMSS and PISA provide plenty of high quality information on achievement and context to encourage focused research and meaningful interpretation. PISA 2006 included more than 400.000 students in 57 countries (OECD, 2007a) and provided plenty of interesting results for Slovenia with fairly good overall impression (Štraus, et al., 2007). However, even simple questions can have difficult answers.

SIMPSON'S PARADOX

Statisticians have long known that data can give ambiguous answers when approached differently. Specifically, the phenomenon where the probability of some event (i.e. that boys perform better than girls) increases in given population but decreases in every subpopulation is known as reversed effects or as Simpson's paradox (Kocik, 2001). It was first encountered by Karl Pearson in 1899 (Pearl, 1999) and later thoroughly explained by several authors (Blythe, 1972; Pearl, 1999).

One practical example from educational setting would be the 2006 US School study (Braun et al., 2006) where they compared public and private schools on their student performances. They reported findings that while math and reading levels were higher in private schools than in public schools, comparisons on demographic subgroups showed much smaller differences in both directions. Other examples can be found in various fields (Wagner, 1982).

Whenever Simpson's paradox occurs, it presents a challenge to the interpretation of results. If interpretation on one level opposes the interpretation of same results broken down by groups there should be an exploration into causes of such a shift and an increased attention when interpreting data.

RESULTS FOR BOYS AND GIRLS IN SLOVENIA

In this paper we explore PISA 2006 results for boys and girls. Gender differences are high on the list of main findings of educational studies and they are often reported, cited and used in setting educational policies. Table 1 shows performance of Slovenian students on PISA 2006 science achievement broken down by gender and different educational tracks. (Results were calculated from all five plausible values using SPSS Replicates module provided by ACER.)

Scores are reported on a common scale with 500 points as an OECD average. The educational tracks in table 1 are coded as: GIMg – 4-year general gymnasia, GIMs – 4-year technical gymnasia, STSI – 4-year technical education, SPI – 3-year vocational education and NPI – 2-year vocational education.

Table 1: PISA 2006 science achievement for Slovenia by educational track

Educ. track	Total	*S.E._total*	Girls	*S.E. Girls*	Boys	*S.E. Boys*	Diff.	*S.E. Diff.*
GIMg	599	1,9	590	2,2	614	3,9	**-25**	*4,7*
GIMs	544	2,4	528	4,0	560	3,5	**-32**	*5,7*
STSI	495	1,6	483	2,7	504	2,2	**-21**	*3,7*
SPI	421	1,9	406	3,0	429	2,5	**-23**	*3,9*
NPI	363	4,8	354	10,7	365	4,9	**-11**	*11,0*
TOTAL	523	*1,0*	526	*1,7*	519	*1,8*	**7**	*2,9*

*Note: One category was eliminated from original data, since it's not comparable (it depicts students still in primary education, while others are tracks of secondary education) and accounts for 3.7% of the population.

While boys outperform girls in every educational track, the girls outperform boys when results are combined, which is a clear case of Simpson's paradox. Explanation for the change can be tracked to different proportions of boys and girls in educational tracks as shown in Figure 1. When different tracks are combined the result for girls increases since most girls are in better performing tracks and result for boys decreases since boys prevail in lower performing tracks.

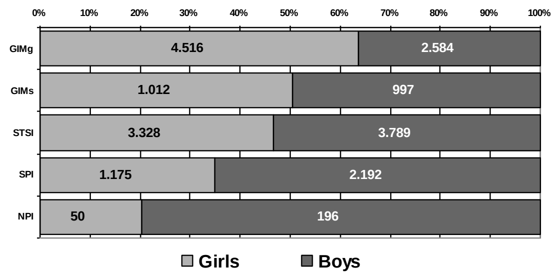

Figure 1: Proportions of boys and girls in different educational tracks as reported in PISA 2006 results for Slovenia. Numbers in bars represent size of the subpopulation.

To picture this relationship more clearly Simpson's paradox can be readily observed from Figures 2 and 3 where distributions of scores are plotted by gender for each educational track (Figure 2) and combined (Figure 3). Dots in each graph represent averages for subgroups of boys and girls.

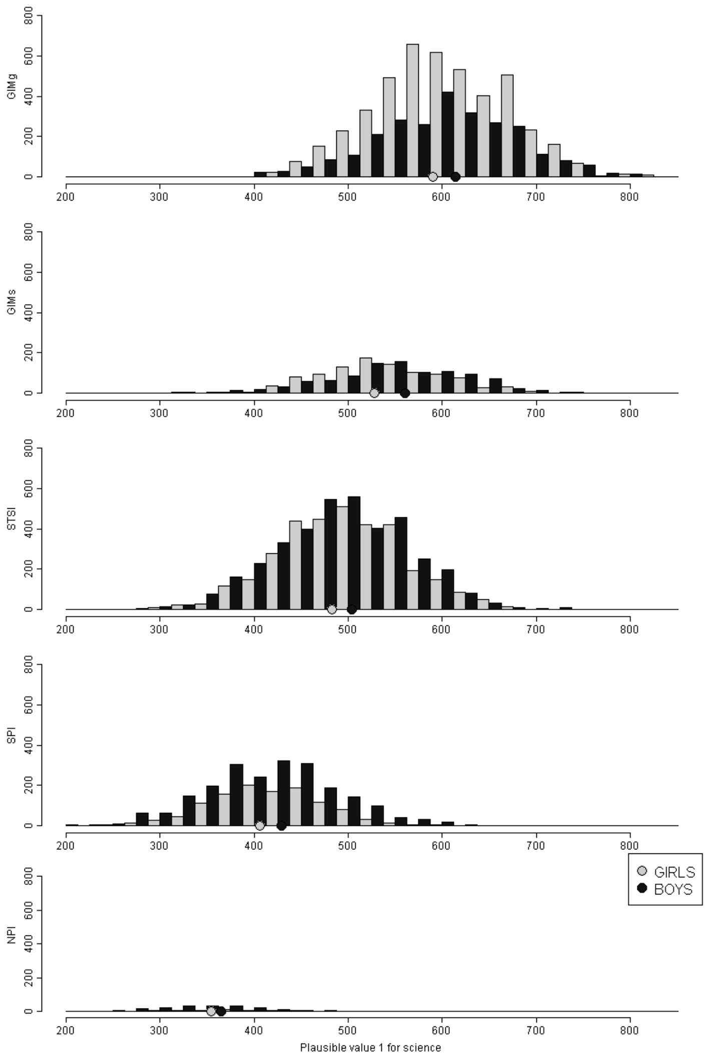

Figure 2: Distributions of PISA 2006 science scores in Slovenia by gender for each educational track.

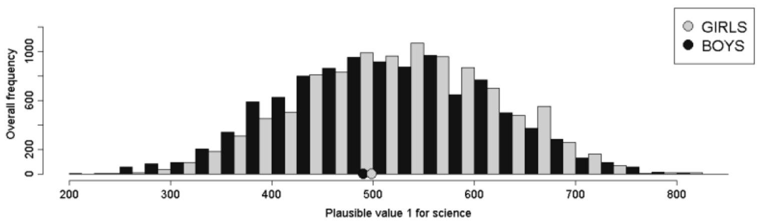

Figure 3: Distributions of PISA 2006 science scores in Slovenia by gender (overall results).

While boys outperform girls in every educational track overall results clearly show that this is more an effect of different gender proportions in different tracks than a real difference between gender subgroups. This can be verified by crosschecking the results from science achievement with those in the areas of reading and mathematics. Tables 2 and 3 show Slovenian PISA 2006 results for reading and mathematics respectively. In reading (Table 2) all the differences are in favour of girls and in mathematics all in favour of boys (Table 3). Nevertheless we can clearly observe the trend where aggregated results are always more favourable to girls than results by educational tracks are. Since the trends are similar regardless of the competency measured we can assume that causes behind such an effect are not specific to competency in science and can be indeed explained well with proportions of each group in specific educational track as shown in Figure 1.

Table 2: PISA 2006 reading achievement for Slovenia by educational track

Educ. track	Total	*S.E._total*	Girls	*S.E. Girls*	Boys	*S.E. Boys*	Diff.	*S.E. Diff.*
GIMg	566	1,6	574	1,9	553	3,1	**21**	3,7
GIMs	520	1,8	526	2,7	514	3,0	**12**	4,5
STSI	476	1,5	493	2,2	460	1,9	**33**	2,9
SPI	399	1,5	420	2,5	388	2,1	**31**	3,6
NPI	302	4,6	320	9,0	298	5,1	**23**	9,9
TOTAL	497	0,8	523	1,3	471	1,6	**52**	2,4

Table 3: PISA 2006 mathematics achievement for Slovenia by educational track

Educ. track	Total	*S.E._total*	Girls	*S.E. Girls*	Boys	*S.E. Boys*	Diff.	*S.E. Diff.*
GIMg	578	2,0	566	2,2	599	3,4	**-33**	3,9
GIMs	527	2,5	504	3,5	550	3,7	**-46**	5,3
STSI	480	1,5	461	2,5	497	2,3	**-36**	3,7
SPI	414	1,7	396	2,7	425	2,0	**-29**	3,2
NPI	392	4,2	363	10,5	399	4,5	**-36**	11,4
TOTAL	508	1,0	504	1,7	511	1,6	**-7**	2,7

RESULTS FROM OTHER COUNTRIES

Although findings have interesting implications for Slovenian results, we can further explore generalizability of findings by including results from other countries. We include PISA 2006 science results for five other central European countries that participated in PISA 2006 – Croatia, Czech Republic, Hungary, Slovak Republic and Austria. All results were again calculated from all five plausible values for science using SPSS Replicates. Since educational tracks in different countries are not directly comparable only mainstream tracks were used in analysis to account for at least 95% of the population covered in PISA 2006.

CROATIA

Mainstream educational tracks are in case of Croatia coded as follows: GYMN – 4-year gymnasium, VOC – 4-year vocational education, IND – 4-year industrial education, PROF – 3-year vocational and profession schools. Three additional subgroups were excluded from analysis because they were either not eligible or they covered very small proportion of the population. (Source: National PISA 2006 report obtained 10. 2. 2010 on http://www.pisa.hr/)

As Table 4 shows, results for Croatia also feature a case of Simpson’s paradox in gender differences although standard errors also allow different interpretation. Differences in specific educational tracks are nevertheless not followed on aggregate level and this can be described by proportions of girls and boys by educational tracks as shown in Figure 4.

Table 4: PISA 2006 science results for Croatia by educational track

Educ. track	Total	*S.E.*	Girls	*S.E. Girls*	Boys	*S.E. Boys*	Diff.	*S.E. Diff.*
GYMN	565	3,7	554	3,9	584	4,0	**-30**	*3,4*
VOC	493	3,4	479	4,0	507	4,0	**-28**	*4,7*
IND	421	6,6	410	6,8	429	9,6	**-19**	*11,7*
PROF	420	2,9	408	4,5	425	3,5	**-18**	*5,7*
Total	494	2,3	495	2,9	493	3,3	**2**	*4,1*

Note: Category of primary schools was excluded, since it is not a secondary education track. Categories of 4-year art education and lower vocational education were excluded since their large standard errors on total score lead to unstable differences. All excluded categories account for only 2.8% of the population.

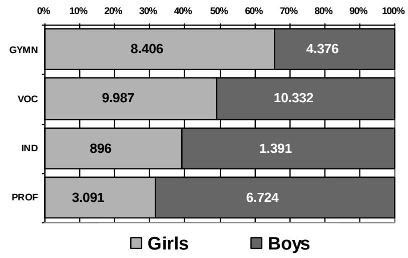

Figure 4: Proportions of boys and girls in different educational tracks as reported in PISA 2006 results for **Croatia**. Numbers in bars represent size of the subpopulation.

CZECH REPUBLIC

In Czech Republic educational tracks in Table 5 are coded as: GRAM – lower and upper secondary grammar schools, GYMN4 – 4-year gymnasiums, SOŠm – upper secondary technical or vocational schools that end with matura, SOŠ – other upper secondary vocational schools, ZAKL – compulsory schools that offer primary and lower secondary education.

Results in Table 5 are close to changing signs on aggregate level. The difference on aggregate level is again much more in favour of girls than on any specific educational track and Figure 5 shows familiar overrepresentation of girls in more demanding tracks as opposed to boys.

Table 5: PISA 2006 science results for Czech Republic by educational track

Educ. track	Total	*S.E.*	Girls	*S.E. Girls*	Boys	*S.E. Boys*	Diff.	*S.E. Diff.*
GRAM	628	6,4	617	6,6	642	7,0	**-25**	*4,4*
GYMN4	613	10,1	609	12,0	625	8,7	**-16**	*10,3*
SOŠm	542	5,7	525	6,8	556	7,9	**-31**	*10,6*
ZAKL	489	3,2	481	3,9	494	3,6	**-13**	*3,7*
SOŠ	443	*9,0*	413	*17,4*	453	*7,0*	**-40**	*16,0*
Total	518	*3,5*	516	*4,7*	520	*4,3*	**-3**	*5,6*

Note: Since in Czech Republic large proportion of 15-year old students is still in compulsory education, this category (ZAKL) remains in the analysis. Two categories were excluded since their large standard errors on total score lead to unstable differences. They account for 3.8% of the population.

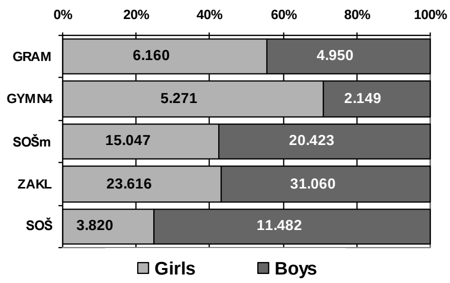

Figure 5: Proportions of boys and girls in different educational tracks as reported in PISA 2006 results for **Czech Republic**. Numbers in bars represent size of the subpopulation.

HUNGARY

In Hungary, Study Programme variable in PISA 2006 was coded to represent four different types of school: GYMN – 4-year grammar or gymnasium schools, VOC4 – 4- year vocational secondary schools, VOC3 – 3- year vocational schools and lower secondary schools. Last group was excluded from analysis, since it represents students, who are still in lower secondary education and didn't choose their educational track yet.

(information was obtained through personal communication with Ildikó Balázsi, NPM for PISA 2006 in Hungary.)

Results for Hungary in Table 6 are not a case of Simpson's paradox but it is clear that differences in each educational track are much greater than with results combined. Proportions of girls and boys in each educational track in Figure 6 again readily explain this effect with larger proportions of girls in more demanding tracks.

Table 6: PISA 2006 science results for Hungary by educational track

Educ. track	Total	*S.E.*	Girls	*S.E. Girls*	Boys	*S.E. Boys*	Diff.	*S.E. Diff.*
GYMN	561	4,6	550	4,1	576	7,1	-27	6,1
VOC4	507	3,5	492	4,7	522	3,8	-30	4,8
VOC3	431	4,0	419	4,7	437	4,4	-19	5,0
Total	513	2,6	507	3,4	519	3,4	-12	4,3

Note: Excluded group represents 7.7% of the total population.

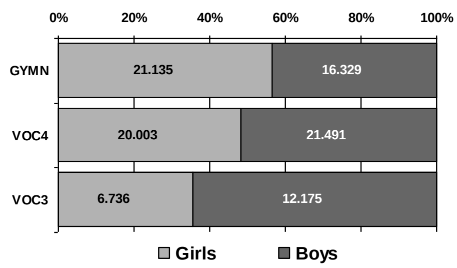

Figure 6: Proportions of boys and girls in different educational tracks as reported in PISA 2006 results for **Hungary**. Numbers in bars represent size of the subpopulation.

SLOVAK REPUBLIC

Codes, corresponding to educational tracks in Slovak Republic, are: GRAM – lower and upper secondary grammar schools, GYMN4 – 4-year gymnasiums, SOUm – upper secondary vocational schools that end with matura, SOU – upper secondary vocational schools, SOŠ – upper secondary vocational schools, ZAKL – compulsory schools that offer primary and lower secondary education.

Table 7: PISA 2006 science results for Slovak Republic by educational track

Educ. track	Total	*S.E.*	Girls	*S.E. Girls*	Boys	*S.E. Boys*	Diff.	*S.E. Diff.*
GRAM	592	7,9	584	9,8	601	8,0	**-17**	*9,6*
GYMN4	564	5,2	554	6,5	580	5,2	**-26**	*5,6*
SOŠ	502	*4,5*	488	*3,8*	521	*7,8*	**-33**	*7,5*
SOUm	473	12,0	449	9,8	483	12,7	**-34**	*11,1*
ZAKL	464	5,1	457	6,0	469	5,6	**-13**	*5,5*
SOU	416	*8,5*	407	*10,5*	420	*9,3*	**-13**	*9,7*
Total	490	*2,8*	487	*3,2*	494	*4,1*	**-7**	*4,6*

Note: Since in Slovak Republic large proportion of 15-year old students is still in compulsory education, this category (ZAKL) remains in the analysis. Two categories were excluded and they represent 1.7% of the total PISA population.

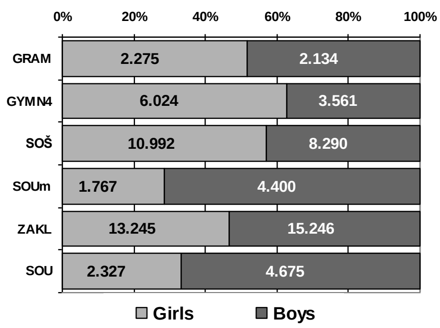

Figure 7: Proportions of boys and girls in different educational tracks as reported in PISA 2006 results for **Slovak Republic**. Numbers in bars represent size of the subpopulation.

AUSTRIA

Eleven different codes were used for Study Programme variable in Austria's PISA 2006 data. After inspection, only six indicated mainstream educational tracks as follows:

GYMN-Gymnasium Lower Secondary, HVOC-Higher vocational school, MVOC-Middle vocational school, APPR-Apprenticeship, POLY-Vocational Programme, HAUPT-Lower Secondary school (information was obtained through personal communication with Claudia Schreiner, NPM for PISA 2006 in Austria and Ursula Schwantner)

Austrian data in Table 8 shows only general dynamic of diminishing differences in aggregated data. Similary also the Figure 8 shows less explicit trend of increased proportion of girls in more academic tracks of education.

Table 8: PISA 2006 science results for Austria by educational track

Educ. track	Total	*S.E.*	Girls	*S.E. Girls*	Boys	*S.E. Boys*	Diff.	*S.E. Diff.*
GYMN	578	4,8	574	6,2	584	4,2	**-9**	5,7
HVOC	558	4,2	544	4,6	573	4,6	**-30**	5,0
MVOC	469	16,4	442	17,2	500	16,9	**-58**	20,5
APPR	460	5,2	435	6,7	472	5,2	**-37**	8,8
POLY	437	8,6	418	10,5	447	8,3	**-30**	6,5
HAUPT	404	13,4	386	19,7	414	12,7	**-28**	16,5
Total	512	4,1	508	5,5	516	4,2	**-9**	5,5

Note: Five codes were excluded for their small proportion of the population and large standard errors. They account for 4.3% of the population.

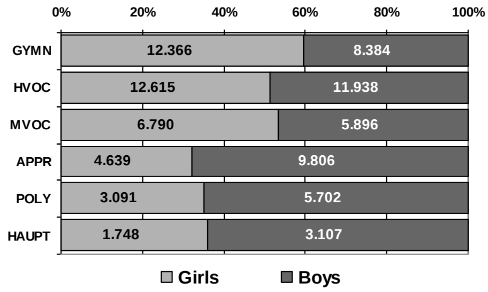

Figure 8: Proportions of boys and girls in different educational tracks as reported in PISA 2006 results for **Austria**. Numbers in bars represent size of the subpopulation.

CONCLUSION

Apart from purely academic interest in issue of Simpson’s paradox this research has also profound implications for practical use of PISA 2006 results by generalization of findings to other PISA cycles and international educational studies.

First reminder should always be that conclusions based upon results from subgroups don’t apply to the overall picture even when they all point in the same direction. Simpson’s paradox is not an obscure statistical peculiarity with low probability of occurrence. As demonstrated above reversed effects can be readily observed from real data and they do present a challenge to the adequate interpretation of results. In above results, unequal proportions of boys and girls that can lead to reversed effects were more or less present in all selected countries and should be strongly considered especially when interpreting results of such international studies by educational tracks.

Even more important is the other aspect of this research. There seems to be a systematic effect, observable in Slovenia and other countries included in the comparison, where boys and girls apply to different educational tracks in such a way as to maximize the differences in favour of boys in different tracks. Except in some usually small stratums of population in most cases it was clear that overall difference between boys and girls was more favourable to girls than results by educational tracks were. PISA 2006 results for Slovenia demonstrate this effect in science, reading and mathematics, although the change of signs that leads to Simpson’s paradox only surfaced in the science achievement. In other countries similar trends can be observed.

The trend stems from the fact that more girls than boys selected more demanding educational tracks. Since subgroup of boys in demanding tracks is smaller it is also more homogenous in it's relatively high achievement in those groups relative to the larger group of girls. In less demanding educational tracks the trend is reversed. Subgroup of girls is relatively smaller and relatively more homogenous in their (lower) achievement than their male peers in same track. This accentuates differences in each educational track in favour of boys compared to the overall differences and is a driving force behind observed Simpson's paradox.

This research lacks other perspectives like sociological, psychological or school policy evaluation that could give insight into dynamics creating observed differences between results on the level of whole country and results, broken down by educational tracks. Since this is a complex dynamic probably involving myriad of individual, sociological, societal, economic and other factors it remains a challenge for further research. However, this dynamic is being currently neglected in evaluation of gender differences in PISA, as done by OECD (2009) and could prove valuable if thoroughly researched. Databases of international educational studies seem more than appropriate starting point for such a task.

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THE TIME IS RIGHT: EMBEDDING EDUCATION FOR SUSTAINABLE DEVELOPMENT INTO PRE-SERVICE SCIENCE AND TECHNOLOGY TEACHER EDUCATION

Lyn Carter

AUSTRALIAN CATHOLIC UNIVERSITY

MELBOURNE CAMPUS

lyn.carter@acu.edu.au

Caroline Smith

AUSTRALIAN CATHOLIC UNIVERSITY

MELBOURNE CAMPUS

caroline.smith@acu.edu.au

ABSTRACT

Against the background of the now urgent need for transitions to a sustainable future, this paper discusses pre-service education for sustainability (EfS/ ESD) within science education. Effective teacher education is a key enabler for EfS/ ESD and pre-service teachers require substantially more education in the area than they currently receive in most tertiary institutions. EfS/ESD is a complex, transformative and transdisciplinary field associated with particular pedagogies, content and processes and most effectively delivered through a whole-of-system approach. The Australian Sustainable Schools Initiative (AuSSI) provides a useful platform for considering pre-service EfS/ESD, tying in with EfS/ESD practice in an increasing number of Australian schools. This paper argues for pre-service teacher education for sustainability within science education and reports on a formal evaluation of embedding five AuSSI modules into the semester long second-year unit EDST 204 Science & Technology for Primary Teachers 2 within the Bachelor of Education degree for primary (elementary) pre-service teachers at the Australian Catholic University in Melbourne. The findings of this evaluation speak to the implementation of EfS/ESD more broadly within pre-service teacher education.

Keywords: *Pre-service teacher education, education for sustainability, the Australian Sustainable Schools Initiative (AuSSI)*

INTRODUCTION

Recent years have seen an increasing acceptance of the ecologically fragile state of our world with its vast human load beginning to exceed carrying capacity. The issues of environmental sustainability have been identified in significant international reports and meetings including the 1992 United Nations Conference on Environment and Development that produced the blueprint for the global implementation of sustainable development - *Agenda 21,* and the 2000 United Nations General Assembly's *Millennium Declaration.* More recently, we have seen the highly influential Intergovernmental Panel on Climate Change **(**IPCC**)** *Climate Change 2007*, the *Stern Review on the Economics of Climate Change* (2007), while not forgetting Al Gore's *The Inconvenient Truth* and the disappointing if iconic 2009 United Nations Climate Conference in Copenhagen. Already published this year is the Worldwatch Institute's *State of the World* report (Assadourian & Yunus, 2010). Together these documents and meetings argue that hyper-consumption levels fuelled by carbon-based energy have fundamentally altered the planetary conditions for life. They also argue that profound changes to humanity's collective cultural values are required if we are to reshape our relationships with the natural systems of which we are part and upon which we depend.

It is now also widely accepted that education is one of the most effective means we have of bringing about such cultural change needed for the transition to sustainability. Indeed, the highly significant *Agenda 21* emphasized the role of education in the move towards an environmentally sustainable future:

> Education is critical for promoting sustainable development and improving the capacity of the people to address environment and development issues (Chapter 36, Para 36.3).

Adopting a similar perspective, the United Nations General Assembly declared the years 2005 to 2014 to be the Decade of Education for Sustainable Development (UN DESD), inviting participation from governments worldwide. Within in our context, Australia was well placed to respond with the release of the first *National Action Plan for Education for Sustainable Development* (NAP) in 2000, and the subsequent establishment of the *National Environmental Education Council (NEEC)* that commissioned a review of nationwide curriculum documents and identified national priorities. Pilot sustainable schools programs in New South Wales and Victoria were implemented as a result. *Educating for a Sustainable Future – A National Environmental Education Statement for Australian Schools (NEES)* followed in 2005, and provided a nationally agreed vision and implementation framework of the nature and purpose of environmental education for sustainability through all years of schooling. Positive evaluation of pilot sustainable schools programs lead to the development of the Australian Sustainable Schools Initiative (AuSSI) gradually spreading throughout the all states by 2008. *Caring for Our Future -The Australian Government Strategy for the UNDESD* bought together a number of these schemes and foreshadowed the development of the second NAP, *Living Sustainably: the Australian Government's National Action Plan for Education for Sustainability* released in 2009.These and other policy initiatives by the Australian Government have recently been cited as amongst world’s best practice in the report *Climate Change and Sustainable development: The Response from Education* released in 2009 (Læssøe, Schnack, Breting & Rolls, 2009).

Given that what is at stake in environmental degradation are climate change, desertification and destruction of agricultural land, the depletion of forests, loss of biodiversity and species habitat, and the pollution of the atmosphere, waterways and oceans, science education seems a natural space for education about and for environmental sustainability (EfS). In an excellent overview, Gough (2008) describes the lengthy relationship between science education and environmental education, arguing in essence, that their relationship has strengthened with the growing recognition of the necessity of environmental sustainability. Gough (2008) quotes Jenkins and Pell (2006) to conclude that since many environmental problems (and their solutions) are science related, then there is clearly a role for school science education, and goes onto argue that:

> (b)y bringing science education and environmental education together in the school curriculum, science content is appropriate to a wider range of students and more culturally and socially relevant. The convergence is also important for environmental education, because it needs science education to underpin the achievement of its objectives and to provide it with a legitimate space in the curriculum to meet its goals (p.41).

Moreover, she believes that EfS should be part of any approach to science education that attempts to address the decline of students’ interest in school science apparent from many studies by those like Dekkers and de Laeter (2001), and perhaps most significantly, the extensive Relevance of Science Education (ROSE) Project (Schreiner & Sjøberg, 2004). Indeed, the recent addition of a strand of interest - Strand 14 Environmental Education- within the world’s largest science education research organisation, the United States based National Association for Research in Science Teaching (NARST) would seem to support a belief in the mutualism (Gough’s 2000 term) between science and environmental education.

As many science teachers, and particularly primary (elementary) science teachers, do not possess a viable knowledge and background in environmental education, it is not surprising that EfS or education for sustainable development (ESD) is currently absent from much school science curricula. Effective future pre-service teacher education will be a key enabler for the development and implementation of appropriate EfS/ESD. Hence, this paper argues for pre-service teacher education for sustainability within primary science education as a natural place for EfS/ESD, and outlines the Australian Sustainable Schools Initiative (AuSSI) as a new generation program that can provide a useful framework for pre-service teacher EfS/ESD. In addition, it reports on a formal evaluation of embedding five AuSSI modules into the semester long second-year unit *EDST 204 Science & Technology for Primary Teachers 2* within the Bachelor of Education degree for primary (elementary) pre-service teachers at the Australian Catholic University in Melbourne. The findings of this evaluation speak to the implementation of EfS/ESD more broadly within pre-service teacher education. We begin this discussion then, with a brief review of the shift in perspective from environmental education to EfS/ESD.

THE MOVE FROM ENVIRONMENTAL EDUCATION FOR SUSTAINABILITY AND EDUCATION TO EDUCATION FOR SUSTAINABLE DEVELOPMENT (EFS/ESD)

Environmental education as a separate field had its origins in the ecological degradation identified by Rachel Carson in her 1962 book *Silent Spring* (Gough, 2008). Throughout the 1970's, culminating in the 1977 landmark Tblisi declaration that called for formalized environmental education for the first time, early environmental educators emphasized a scientific knowledge base focussed on natural subsystems (Tilbury, 1995). Nature-society interactions were usually reduced to a series of inputs or outcomes (Reid & Scott, 2006). Over time, and as the inadequacy of this somewhat one-dimensional approach became apparent, there was a substantial shift towards the promotion of sustainability and sustainable development (Gallopin, 2002). Initially endorsed by the World Conservation Strategy in 1980 and later by the 1987 Brundtland Report, education for sustainability called for the development of a conservation mindset within environmentally sound values as well as understanding the sustainable use of natural resources. Bonnet (2002) tell us that it was based on the three requirements of the maintenance of life-support systems, the preservation of genetic diversity (extending to species and habitat diversity), and the sustainable use of natural resources. At the same time as calling for people's increased participation in the conservation and management of their own environments, education for sustainability proactively aimed to prevent problems arising rather than cleaning up the mess afterwards.

Firmly embraced by the 1992 United Nations Conference on Environment and Development - *Agenda 21*, this newer approach placed humans into the system, recognising the roles played by historical, socio-cultural and economic-political assemblages on underlying worldviews and power structures. EfS/ESD problematises and exposes these interrelationships that shape global, national and local responses to issues around sustainability, including multicultural and indigenous perspectives. Indeed, the Australian Government's 2009 NAP- *Living Sustainably* argues that

> "the focus has shifted from knowledge of the natural ecosystems and threats posed to them by overuse and deletion of resources to equipping all people with the knowledge skills and understanding necessary to make decisions based upon full environmental, social and economic implications" (p.10).

There is much agreement that EfS/ESD is a promising development but its sheer complexity encompassing as it does the integration of so many areas of human endeavour, perhaps not surprisingly, invites significant conflict. For example, it raises issues about whether EfS/ESD' central purpose is primarily educational or more broadly social, reflecting the greater tension between environmental protection and development and social justice arguments. Moreover, sustainability itself is a term with multiple meanings and descriptions, anywhere from ecocentric attempts to move away from economic growth, to those which argue that it disguises what is to be sustained, namely a Western affluent lifestyle (Smyth, 2005). Indeed as Gough (2008) points out, while the broader sustainability agenda around the social and economic includes health, poverty and redistributive justice agendas, in the developed world, EfS/ESD tends to remain focussed on the natural environment despite attempts by those like Reid, Bjarne Bruun, Nikel and Simovska, (2008) and Smith (2009) to incorporate these broader agendas.

While the 2009 report *Climate Change and Sustainable development: The Response from Education* devotes a full chapter to the divergent interpretations and meanings of EfS/ESD, it is suffice here to make a number of general observations about characteristics of EfS/ESD within our context. These include that EfS/ESD:

- is concerned with how people interact with their total environment and with addressing environmental problems holistically through the curriculum. Hence, holism is its philosophical basis.
- employs 'synthesis' as a methodological approach which assumes that studying interdependence and interactions leads to the emergence of new properties.
- investigates the environment at different environmental scales. This means investigations of different local, regional, national and global environmental problems and an exploration of the their links.
- recognises that engagement in environmental improvement extends beyond the cognitive to a individual sense of responsibility generated by a personal environmental ethic. Thus, central to the success of EfS/ESD is the promotion of an environmental ethic which has sustainable living at its core. This includes developing an understanding of place and a deepening connection to nature.
- tends to involve issue-based learning through relevant concepts, values and morality: (i) identifying issues; (ii) investigating issues; (iii) seeking solutions to issues; (iv) carrying out actions to address issues; and (v) evaluating the impact of the environmental actions taken to resolve these issues. It is not merely about discussing solutions to enhance awareness; rather it is purposeful and active exploration of issues, and the identification and enaction of potential solutions.

Clearly, if schools are to be proactive in implementing EfS/ESD of this type either within their science programmes or elsewhere, then EfS/ESD needs to become a core element in both in-service and pre-service teacher education. Indeed, the 2004 evaluation mentioned above of the Victorian pilot sustainability schools project developed by the Centre for Education and Research in Environmental Strategies (CERES) and the Gould League, made 16 recommendations for forwarding the EfS/ESD agenda in that Australian state. Recommendation 10 identified the importance of ‘ongoing professional development and pre-service training in environmental education for teachers in Victoria’ (Larri, 2004 p.12).

PRE-SERVICE TEACHER EDUCATION

In addition to the other policy and programme initiatives already described, in 2003 the Australian Government established the Australian Research Institute in Education for Sustainability (ARIES) at Macquarie University. ARIES conducted a general review of environmental education/EfS/ESD in Australia across all sectors including pockets of good practice in pre-service teacher education, in an attempt to identify opportunities, incentives and constraints that could impinge upon the mainstreaming of EfS/ESD (Ferreira, Ryan & Tilbury, 2006). The ARIES report evaluated models of pre-service EfS practice including (1) the collaborative resource development and adaptation model, a largely one-off program approach; (2) the action research model, and (3) the whole-of-system model. Ferreira et al. (2006) found that core features of the action research model, when combined with the whole-of-system model, provided the best combination for successful mainstreaming of EfS/ESD. The whole-of-system model is a complex layering and networking of all elements within the pre-service teacher education context so that the organisational culture, programs and courses, personnel, and procedures and processes work in tandem to bring about change. The authors went on to argue that when combined with action research methodology, the whole-of-system model provides a powerful means for developing practitioners' sense of ownership, autonomy, and ability to bring about change within their own particular setting.

While the ARIES report considers the whole-of-system to be ideal, it is clearly complex and difficult to achieve. Issues of co-ordination, having sufficient committed staff and the need for high level support and resources, means it is not always possible to implement or mainstream on a large scale. Indeed, there is an argument for small scale change as part of a larger strategy of capacity building and longer term, more sustaining, attitudinal and behavioural change. Critical factors for success within pre-service teacher education include the development of a curriculum focus and pedagogical strategies reflective of EfS/ESD principles like those described above such as a holism, environmental ethics, issues-based learning, critical and reflective processes, a transdisciplinary approach, and transformational pedagogies. As well, broadly-based partnerships and networks between teacher preparation institutions and a variety of sectors such as Non Government Organisations (NGOs), inter-governmental bodies, resource centres, and industry bodies, enable a deeper engagement by participants in a diversity of settings, which more likely embeds a long-term commitment to EfS/ESD.

The resultant sustainability-literate teacher graduate would be expected to understand the importance of sustainability, be competent in relevant pedagogies and curricula, have a commitment to social justice and equity, and seek to adopt socially transformative agenda. They would be ecoliterate, which includes an understanding of the dimensions and systems nature of sustainability, an understanding of ecology and planetary biosystems and their limits, empathy and connection with nature (biophilia) (Kellert & Wilson, 1993), knowledge of the role of economics and politics, and empowerment to play a leading role in their creation sustainable societies; a tall order indeed!

THE AUSTRALIAN SUSTAINABLE SCHOOLS INITIATIVE

The above approach to pre-service teacher education fits within the umbrella strategy for implementing EfS/ESD with Australian schools – the Australian Sustainable Schools Initiative (AuSSI). Developed initially in 2004, in general terms AuSSI is one of the new generation of environmental programs that takes schools beyond mere awareness raising to strategy planning, and on to action and, in many cases, environmental leadership. It provides a framework for widespread cultural and organisational change and is introduced as a flexible professional development program for teachers, pre-service teachers, administration staff, parents and other interested groups. The process builds on existing achievements and encourages the involvement of the whole school's local community in shifting towards more sustainable practices and processes. It seeks to develop relationships with other areas that impact on the organisation and management of a school such as NGOs, and resource centres, and assists schools to achieve real-world and measurable social, environmental, educational and financial outcomes.

Each Australian state has its own version of the AuSSI reflecting the diverse historical lines of state-based EfS/ESD. In Victoria for example, AuSSI (Vic) provides a customised program of five modules. They comprise a core module focussing on general issues of the sustainable school, culminating in the development of a customised, holistic school environment management plan that establishes baselines and set targets. The other four are energy (energy conservation, renewable energy, air quality and reduction in greenhouse gas emissions); water (water use, water conservation and storm water management); waste

(waste/litter minimisation and recycling) and biodiversity, (monitoring and developing indigenous and food gardens).

EVALUATING AuSSI (Vic) WITHIN PRE-SERVICE TEACHER EDUCATION

In this section, the evaluation findings of embedding the five AuSSI (Vic) modules into the semester long second-year unit *EDST 204 Science & Technology for Primary Teachers 2* within the Bachelor of Education degree for primary pre-service teachers at the Australian Catholic University in Melbourne are summarised. The evaluation aimed to establish the efficacy with which elements of AuSSI (Vic) as an example of pre-service teacher EfS/ESD has contributed to students' learning. The unit covered 12 weeks' teaching delivered in a weekly one-hour lecture and two-hour tutorial during 2008 (July-October). The lectures introduced and delivered the rationale and key knowledge-base concepts underpinning the five AuSSI (Vic) modules: core module, water, waste, energy, biodiversity. The tutorials provided a small group setting for students to reflect on and discuss the issues from the lectures and to research and present their learning. As the total number of teaching time was 36 hours, not all characteristics of EfS/ESD described in the section above were able to be incorporated into the unit and are hence, not reported on here. Moreover, the unit was not designed to provide substantial curriculum and pedagogical knowledge.

The evaluation consisted of an interpretation of a random sample of students' responses to a baseline survey conducted on-line before undertaking EDST 204, and a post- unit survey at the end. Approximately one-third of the students were included in the sample (N= 33), and the same students were surveyed both times. The post-survey questions included those asked in the pre-survey as well as additional questions specific to the unit. The questions sought information about the students' knowledge base, attitudes and behaviours pertinent to sustainability in general and the AuSSI (Vic) modules in particular. Student responses to questions evaluating their knowledge base are reported below under headings corresponding with the AuSSI (Vic) modules.

KNOWLEDGE BASE

Energy

When asked to give four ways to reduce energy consumption in the home or school, the students showed a strong consistency between their pre- and post-tests, indicating an already significant level of prior learning in this area. This learning could have come variously from their previous school knowledge and the types of solutions heavily promoted by the media. One difference was that in the pre-test, the students did not always discriminate between energy conservation and other types of conservation, citing using grey water, installing a water tank and composting as examples of energy conservation. This understanding improved in the post-test. More significantly though, when asked to explain the connection between energy generation and use and climate change, the pre-test responses were vague, and while the post-test responses were generally better, this appears to be an area that needs further work. A general confusion about the links between climate change, greenhouse gases and the ozone hole was identified. Typical students' comments were:

Pre-test: *S2-The more we use energy the more fuels and gases are released into our environment this leads to climate change.*

Post-test: *S2-The majority of countries burn fossil fuels to generate energy as electricity. The CO_2 emissions from humans using such energy have increased into the atmosphere. Through the greenhouse effect, the atmosphere becomes choked with gases and the sun's heat cannot escape this haze thus increasing temperatures on earth. This ultimately means, reducing rainfall, increasing hostile storm fronts, melting snowcaps. Deforestation has contributed greatly to the climate change.*

Without the trees to photosynthesise, our air is not as clean and there are fewer trees to do more work to keep us alive

Water

In this section the students were asked about their understanding of the water cycle, water consumption in the home and ways to reduce it. In terms of water use and conservation again there was a strong consistency in the pre- and post-test responses, reflecting a good prior knowledge. While clearly all students had previously formally learnt about the water cycle, their post-test responses indicated a deeper understanding with more recourse to technical language.

Pre-test: *S3 - The movement of water through the following stages:1. evaporation 2. transpiration 3. condensation 4. precipitation 5. Storage*

Post-test: *S3- Clouds are formed over the oceans through condensation. Water particles become heavier, move across land and produces precipitation. Rain falls on land, trees, lakes, mountains (as snow, ice). Water is absorbed by the land, some is used by the trees. Transpiration occurs through the trees photosynthesizing. Evaporation from bodies of water, condensation into clouds again*.

Waste

Here, students were asked about their knowledge of landfill and the importance of composting. The students' knowledge clearly improved as a consequence of the unit, as the pre-test indicated that the level of prior knowledge was relatively low. For example, they had a much greater understanding of the composition and importance of the role of compost in soil health as indicated by the following quotes.

Pre-test: *S4- It is good for the soil. Puts nutrients into the soil. Recycles food scraps.*

Post-test: *S4 - Composting provides an almost constant source of free fertilizer and soil conditioner. The organic materials in the compost help your plants grow by loosening the soil and allowing better root entry. The texture of compost improves the solid ability to hold water and can reduce your water bills. Compost has all the nutrients that plants require, unlike chemical fertilizers. Through regular use of compost you can greatly reduce or even get rid of the need for chemical fertilizers, pesticides and herbicides, which saves money and reduces contamination of our waterways and drinking water.*

Further, the students' knowledge of what went into landfill and why this is problematic increased after studying the unit. This increase in learning can almost certainly be attributed to the unit since it reflects knowledge and understanding not generally promoted in the media and elsewhere. Hence, science and related concepts around waste need to be specifically taught.

Biodiversity

This was a concept that the pre-test data showed as having the lowest level of understanding, and students' understanding of biodiversity improved significantly as a consequence of studying this unit. Not only were they able to identify biodiversity as a major environmental issue in the post-test compared with the pre-test, but they were able to explain and expand on its meaning to include genetic and ecosystem diversity.

Pre-test: *S5- This includes many different things which contribute to our world and maintain its natural flow or existence.*

Post-test: -*S5: Biodiversity is the variety of all living things; the different plants, animals and micro organisms, the genetic information they contain and the ecosystems they form. As a developed nation, Australia has a special responsibility for biodiversity conservation and management.*

The students were also asked to explain what they understood by the terms *food web, habitat* and *ecosystem.* As these concepts are studied at secondary school, it was expected that their prior learning would be evident in the pre-test. While this was the case, the unit contributed to more sophisticated understanding particularly in the students' accurate use of technical terms.

ATTITUDES TO SUSTAINABILITY AND EFS/ESD

Even though 100% of students reported a very positive attitude towards issues of sustainability at the beginning of the unit, and believed they needed to take personal responsibility for their attitudes and actions, they found the unit contributed to raising their consciousness and empowering them towards action. The post questionnaire showed that more students were able to identify and articulate reasons for their attitude, indicating an increased knowledge base and understanding of their own position I terms of values and feelings. This probably reflects the presentations and discussions that took place in depth in the tutorials.

Pre-test: *S6 - Of course, we are all a part of the environment around us, and if we do not care for it ourselves who will?*
Post-test: *S6: Yes, before undertaking this unit I cared about the environment but didn't really know what actions I could take to make a difference I now understand that there is a lot which can be done on a person level.*

A new element at the end of the unit was the significant number (25%) who indicated that the unit had helped them realise the importance of EfS/ESD and had given them a strong basis for educating children. They realise that they will need to be role models for their own students.

Post–test: *S1- My attitude has changed. This unit has made me more conscious of my actions and the impact they have on the environment. Also, I have recognised the importance of this issue and how we, as teachers, can teach students how to live sustainably.*

S2: I do feel a sense of responsibility, especially since I am going to become a teacher, where students I will be seen as a role model. I also believe that while the environment provides for us, we should provide for the environment. Therefore, our effect on the environment, will effect the lifestyle of future generations, so we need to act responsibly in order to ensure an adequate lifestyle for the future."

S3: I was aware of the importance of sustainability before completing this unit. but I have been able to gain further knowledge and build my understandings further which will help me become a successful teacher of sustainability.

The students appeared to have obtained their attitudes from the media, their parents and previous education. A few noted experiential or spiritual reasons. It is highly likely that for many students learning about sustainability is largely cognitive/rational rather than a deeply held experiential or even spiritual connection (ie it doesn't necessarily 'touch' everyone). This probably accords with Gardner's multiple intelligences, where only around 10% of students are considered to have a high naturalistic/experiential intelligence. This has implications for a multi-dimensional approach to EfS/ESD.

Post–test: *S5: We all contribute to and have a huge impact on the world. Only recently has it concerned me, as we are beginning to see exactly what it is doing and will continue to do. I first learnt in more depth about this last year and have continued to follow it through the news and documentaries.*

BEHAVIOURS

The post-test shows a shift towards a clearer articulation of actual concrete behaviours around reduction of consumption and towards a conserver lifestyle. By the end of the unit the students had access to a wider range of options for working towards sustainability. There was also a clear articulation of being conscious and aware of personal impact of the importance of taking personal responsibility, and again there was an increase in the emphasis on education.

Post–test: *S1: We all need to become more conscious and aware of the consequences of our actions/think before acting think about things in our lives that impact the size of our ecological footprint*
S2: Inform and educate others on what they can do.

S3: We need to initiate effective strategies to live by, in order to maintain a sustainable environment. Change the way we live.

To gauge behaviour, students were asked the extent to which they participated in particular pro-sustainability behaviours relating to the 5 AuSSI (Vic) modules. For each item students were required to answer either *mostly, sometimes* or *never.* T-testing was applied to gauge any difference in responses between the beginning and end of the unit.

Responses are graphed below, showing students' engagement in particular behaviours before and after the unit. Overall there was a slight but not statistically significant difference in the behaviours.

SUMMARY OF THE FINDINGS

Overall, it was apparent from the post-test data that the unit contributed to students' knowledge about AuSSI (Vic) as well as positive attitudes towards, and appropriate behaviours around, sustainability on all the assessed aspects. However, the pre-test data indicated that students' prior learning in some aspects of sustainability was already significant. Specifically, a greater depth in answering the questions, the correct use of scientific and technical language and more nuanced and clearly articulated comments reflected a better level of understanding of sustainability concepts after completion of *EDST 204.* All students reported that they had gained much from and enjoyed the unit.

Post–test: S2 - What a great unit. What can we all learn from this unit. Firstly it addressed a real need, a need to do something, a need to educate future generations. It was fun and personally challenging. Most people seem to have no interest in anything to do with sustainability. The answer is to educate them and design projects that make them aware It is up to us as educators of the future to spread the danger and urgency of our need to save the planet. Our personal consumer choices have ecological, social, and spiritual consequences. It is time to re-examine some of our deeply held notions that underline our lives; my attitude towards sustainability has become stronger and I am more prepared to speak out and encourage others to do their but for our planet.

There was also a significant increase in the number of students who felt they could influence children as a teacher which is evidence of the emergence of students' identities as teachers of EfS/ESD.

Post–test: *S5: I thought this unit was very helpful in the teaching career as it is important to teach children about the very issues that are around us*

CONCLUSION

The preliminary evaluation of the unit *EDST204* has convinced us of the importance of a dedicated unit for EfS/ESD, an enabled us to 'fine tune' the curricula and pedagogical strategies. For example, we now know to that as there is considerable level of student prior learning in sustainability, the unit should be taught at a more rigorous level. This means a greater emphasis on content with an increased level of conceptual understanding and technical knowledge, particularly in the most poorly understood concepts of energy, climate change and the ozone hole. Moreover, we could cater better for preferred learning styles and include more issues-based options within the tasks.

It is early days for pre-service teacher education in EfS/ESD. Most Australian teacher preparation courses at primary level include some EfS/ESD but usually as an optional elective taken by students to complete the credit points requirement. Thus there are very few pre-service teachers being skilled in the background necessary to become effective and committed teachers of EfS/ESD. The Australian Catholic University is an exception as EfS/ESD is now a core unit meaning that all primary teaching graduates have the opportunity to engage with the field. That said though, and in tandem with the 2009 report *Climate Change and Sustainable development: The Response from Education,* much more research is required into EfS/ESD pre-service teacher education

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ASSESSMENT FOR LEARNING IN INQUIRY BASED SCIENCE EDUCATION: from an individualistic to A Socio-cultural view

Cristina Carulla

Aalborg University

ccarulla@learning.aau.dk

ABSTRACT

Inquiry Based Science Education praxis is growing in different cultures, social environments and continents. Assessment for learning, whose purpose is to help students through their learning process, has been used as part of inquiry teaching strategies. Assessment judgments are based on the learning evidences of each student and interpreted from a constructivist model where conceptual change and mental representations are explored. During the inquiry lessons, the students learn in groups by developing inquiry thinking when they explore phenomena. The teacher helps students supporting their own inquiry process assessing their answers and activities. The interpretations of learning process from a constructivist learning view do not take into account the impact of the socio-cultural context on learning processes. The current focus of assessment is on the outcomes, achievements and learning processes in the individual mind, and less attention is given to the learning processes during the interactions between the students and the teacher. Thus, adopting socio-cultural learning theories can contribute with a new perspective in IBSE for this assessment process, in which the learning evidence is focused on students' interactions and activities rather than on individual outcomes. In this way, the effect of the socio-cultural context on the learning process can be taken into consideration.

Keywords: *Inquiry Based Science Education, assessment for learning, constructivism, conceptual change, socio-cultural theories, interactions, learning evidences.*

INTRODUCTION

My research takes place in the field of assessment for learning in Inquiry-Based Science Education (IBSE). Inquiry Based Science Education can be seen as "particular way" to teach scientific knowledge and to learn scientific reasoning and contents. This "particular way" is characterized by the fact that "the learners are making sense of new experiences for (not by) themselves, being active in constructing knowledge through their mental and physical activity (not passive receivers), linking new experiences to past ones, testing ideas and reconstructing their own ideas and using ideas from others" (Harlen, 2007). In addition, teachers set activities that encourage that kind of learning experiences, by bringing the learners in contact with physical phenomena, materials, texts, and allowing them to communicate their own ideas and participate in discussions (Harlen, 2007). At the same time, IBSE can be seen as a growing network in different cultures, social environments and continents (e.g. http://www.pollen-europa.net, http://lamap.inrp.fr, http://www.indagala.org/), supported on learning sequences that have been constructed by different experts and practitioners in different countries, bearing in mind that "particular way" of seeing learning and teaching.

On these grounds, a specific view of assessment has emerged, and it has been presented and used by different IBSE researchers, teacher educators, and teachers in different cultural environments. This movement is based on the concept of *assessment for learning*, whose purpose is to help students to learn (Black & Wiliam, 1998). Assessment for learning has become particularly meaningful for IBSE (e.g. www.exploratorium.edu/ifi/workshops, http://www.pollen-europa.net). Assessment for learning in IBSE has been promoted as part of the teaching strategy in order to support students' inquiry experiences in all the typical phases of a learning process. In that sense, the teacher needs to inquire, for instance, if a student knows how to ask questions that are researchable, how to draw evidence-based conclusions, or how to plan and investigate in order to collect evidence and make explanations. Assessment is a tool that the teacher uses to find out how students are doing in each phase, and to help them make progress in their own reconstruction of ideas (Black & Wiliam, 1998). To help the students to learn, the teacher needs to gather information on the way students think, make interpretations about the thinking process, determine how far their knowledge is from the expected learning goals, and adjust teaching activities to secure progress in students' thinking (Harlen, 2006a; Ruiz-Primo & Furtak, 2006).

THE TENSIONS

One of the strong foundations of the IBSE praxis is that during the activities in the classroom, students make their research, discuss and communicate their own ideas and arguments in small groups. The learners work together in order to agree on questions and problems that they want to answer, and use materials, books, Internet or other resources to draw conclusions and explanations related to particular phenomena (Saltiel, 2006). After that, they communicate their ideas to others -–including the teacher– and they discuss them and come to an agreement on what is acceptable for everyone.

According to the main statements of assessment for learning in IBSE, teachers must have information about every learner's process during the different phases and different activities (by themselves, in groups, in classroom discussions) (Ruiz-Primo, Li, Tsai, & Schneider, 2007; Shavelson, et al., 2008). The kind of information needed for the assessment process is that which, in some way, can open a door that gives the teacher access to the learning process taking place inside the learner: "To know how students are doing, teachers need a way to 'get into students' heads' and understand how they're thinking […] assessment will be used to see how students understand science concepts, and how effectively they are using the science process skills" (Harlen, 2006b, 10). The purpose of this kind of assessment is to help the learning process that is happening in every student's head.

However, it is not clear that the communication and interactions around particular problems when the students work together necessarily help every student to learn what teachers expect. At the same time, it is difficult to know about the quality of the processes happening when the students are interacting in groups. The quality of the process depends on the previous knowledge and the language they can use to describe and analyze the facts they are observing in relation to their ideas. Many different factors have been reported as having impact on that quality. For example, (Mercer, Dawes, & Wegerif, 2004) in their research about group work, argue that a "possible explanation for the doubtful quality of much collaborative talk is that children do not bring to this task a clear conception of what they are expected to do, or what would constitute a good, effective discussion". Their interpretation of this statement is that "many children may rarely encounter examples of such discussion in their lives out of school –and teachers rarely encounter their own expectations or criteria for effective discussion explicit to children" (p.361).

Taking into account those facts, I will explore how assessment for learning can be conceptualized from a theoretical perspective that includes the learning process occurring during the group work and in the collective discussions. Certainly when students are working in groups, without the teacher being present, a learning process is going on during their interactions. The teacher has no access to that process and neither to the learning process happening in the students' "heads". The problem of having or not direct access to the individual learning process has been part of the development of assessment research, and there have been many assumptions about the way to access or open that door to the learning process of individuals. Furthermore, different theoretical tools have been developed in order to interpret the learning process happening inside the learners' heads, based on the "learning evidence". Nevertheless, I have not found theoretical assessment tools that take into account the collective learning and thinking processes that take place in different interactional moments.

Therefore, I propose to move from a view of assessment for learning focused on the individual learning development, to one that considers the role of the others in the learning process. For that, I will explore learning theories that support the assumptions and interpretations of learning evidence, and at the same time, conduct the different assessment activities that have been claimed as relevant to help every student to learn in the IBSE assessment research. I will argue that although the relevance of the others for the individual learning process is recognized, the assessment activities have not focused on the role of the others in the individual learning process. I will try to recover the role of others in the assessment activities by focusing the view on the learning process happening during different kinds of interactions. Based on a short IBSE classroom story, I will show the way in which IBSE assessment for learning can work when constructivism-learning theory is adopted, and the particular way to see the contribution of the others to the learning process. After that, I will present another possibility that can be adopted in the IBSE assessment for learning perspective. I will introduce some elements of socio-cultural learning theories that will take part on the assessment, focusing on the collective thinking and learning moments in IBSE classrooms.

DIVERSITY OF MOMENTS IN IBSE CLASSROOMS

In order to substantiate my claims presented above, I will compile fragments of IBSE classroom sessions from experiences shared by teachers, presented in research reports, shown in IBSE videos, and my own teaching. I will organize the fragments in a story that will illustrate certain typical moments in IBSE classrooms. The story will guide my reflections and illustrate the contrast of theoretical perspectives in assessment for learning. I will give each moment the name of a particular space in which different talking, activities, objects, resources and people's expressions interact at the same time, so that each one will give meaning to the whole situation.

In a particular state school in Bogota, before going to the classroom, Blanca, a 4th grade science teacher told me that during the activity that I was about to visit, she would assess the learners' ideas in order to plan the teaching sequences for teaching the students about buoyancy. She told me that at the beginning of the learning sequence, many learners think that the mass of the objects influences the buoyancy (see examples of diversity of stages on understanding about buoyancy of the objects in Furtack & Ruiz-Primo (2007)). She told me that she would collect their ideas at this moment and try to evaluate their capacity to make predictions and hypothesis.

I call **Teacher Own Space –TOS–** the moments in which the teachers prepares the teaching by themselves, as well as those in which they think and act during the class without interacting with others: they talk to themselves and make decisions about materials, activities and uses of time by their own. In the story, for example, Blanca brings to the classroom 11 aquaria, 11 sealed containers with something inside (Object A), 11 sealed smaller and thinner containers than the first ones (Object B), filled with the same material as the former containers. She organizes the materials on the front table. Then, she sticks a big poster on the wall. The poster has a table with three columns. There are drawings of the objects in the first column. There is a label that says "*what will happen"* in the second one. And there is a third column headed with the question "*why does the group think it will be floating or sinking?"* At the same time, she puts 41 copies with questions on the table.

By **Collective Space –CS–** I mean the moments when the teacher and the children are sharing ideas all together: talking about something they are looking at, writing on the board, or answering and asking questions in a way that the thinking is available to everyone in the room. Back to the story, in front of ten groups of 4 learners each, all sitting at their own tables, Blanca invites each learner to imagine what will happen if they introduce a *sealed container with something inside* and a *smaller and thinner sealed container*– she shows the objects A and B– in the aquarium that is full of water. First, she discusses with the kids all the possible outcomes. One child goes to the board and makes a drawing that illustrates the discussion: it is a representation of the aquarium and the 3 possible outcomes that they agree may occur. If the object stay on top of the water, they say it floats. If it is in the middle of the aquarium, they say it sinks. If it goes to the bottom, they say it sinks completely. Later, Blanca asks them to raise their hand if they think the first object will float. She counts the number of hands raised and writes the number followed by the symbol "F" in the second column of the poster. Then, she repeats the questions for the other possibilities and writes the number of questions for each possibility followed by "S" or "SC", depending on the case.

The **Learner Own Space –LOS**– are the moments in the classroom when the learners themselves are drawing, writing on their notebook, touching or looking objects, and reading books or browsing the Internet. They are talking to themselves and making decisions and thinking on their own. Continuing the story, each learner is writing, on the paper that Blanca gave them, their ideas about what will happen to each one of the objects in the water and explaining why they think this will happen in such way. Juan writes on his notebook that the *Object A* will sink because it is heavy. Maria writes that it will sink because it is heavier than the *object B*… Pablo looks around and seems not to be sure about what his answer will be.

I call **Shared Own Learner Space –ShOLS–** those moments when the learner and the teacher are sharing their ideas, asking questions and answering them, doing activities together. The teacher shows something to one learner, and asks questions. The student answers or asks questions, and shows things to the teacher. In the story, for instance, Blanca sees Pablo hesitating, so she goes to him and asks: "what are you thinking?" He answers: "I am not sure if it floats or if it just stays in the middle –showing the object A with his finger. I am sure that it will not go to the bottom". Blanca takes the object A and gives it to him. Pablo takes it in his hands and makes movements. Then, he says: "Now I know, it will stay in the middle." Blanca asks him: "Why do you think that the object A will stay in the middle of the water?"

By **Collective Group Space –CGS–** I mean the moments when the teacher addresses to all the groups of students by asking questions, sharing activities and promoting discussions. The teacher asks the group to share ideas about their common activities, and asks questions to them. In our story, Blanca says that each group must discuss their answers, agree on the one that seems the best for all the groups, and decide how the group will support their explanations. Then, she gives each group an aquarium full of water and the objects A and B. She asks each group to see what happens and to write one explanation for what they are observing. When all the groups have finished, she asks every group to stick their papers on the wall, and explain and communicate their thoughts to the other groups.

The **Group Own Space –GOS–** are the moments when two or more children are sharing ideas, talking, making activities together, or sharing a common task. Continuing the story, for example, Maria, Juan, Pablo and Ana, as a group following Blanca's instructions, are seeing that the Object A is in the surface of the water and the object B is in the bottom. Ana says happily to the others: “Yes! It is as I thought.” Maria and Juan seem surprised, and Pablo experiments pushing the object A to the bottom. The object returned to the surface after he stopped pushing it down the water. After they discussed and wrote their ideas on a poster, Ana went to the wall, stuck it to the wall and explained to the other groups what they had found.

Finally, I call **Shared Own Group Space –ShOGS–** those moments when the teacher talks and shares one activity carried out in one small group of learners. The teacher asks questions, looks whether there is agreement on the ideas or not, or points to a particular object and shows something that is happening. Back to the story, Blanca goes back to Maria, Juan, Pablo and Ana ‘s table and shows with the finger the object that is on the right side of the aquarium, asking: “why do you think this object is at the bottom?” Maria answers: “Because it is heavy”. Juan interjects: “No, it is because it is heavier than the other.” Blanca asks how can they know who is right between Maria and Juan. Pablo proposes to find out the weight of each object to see which one is the heaviest. They found out that the object A was heavier than the object B. Juan said: “I do not understand.” Maria asks Blanca: “Why?”

In what follows, I will interpret these different types of spaces happening in IBSE classrooms, with a focus on assessment, from two different theoretical perspectives. My intention is to evidence the shortcomings of theories of assessment focusing on the individuals’ cognitive change. I will show what a view of assessment building on socio-cultural theories can offer to interpret students’ learning.

THE INDIVIDUALISTIC POINT OF VIEW IN ASSESSMENT

One argument that supports the relevance of the IBSE educational approach is that the current way to teach science does not help students to change their understanding about the physical world. IBSE promotes a pedagogical structure that allows students to express their theories and explanations, building on previous experiences outside and inside the classroom, in order to develop argumentations that are more appropriate. This is, arguments should be expressed in a more scientific language (e.g. Furtack et al. (2007)). The purpose of assessment for learning, as part of this pedagogical structure, is to help each student to review and modify their conceptions by confronting their own explanations with evidences that either support or not their own view. For instance, a possible interpretation about Juan and Maria’s surprise when they saw the Object A floating, is that the theory they had built during their previous experiences does not work for this particular case. At the same time, it is possible to interpret that Blanca wanted to elicit their theories in order to give feedback to them, or provide them with new experiences that will help them to modify their own theories. Thus, she asked them to write, before they actually observed the objects in the water, their justifications for their prediction. What they wrote on the paper would open the door to the thinking happening in their head.

Figure 1 shows the constructivist model that is presented in some IBSE documents to support this view. Taking this model, one could interpret that when Pablo, Maria and Juan were writing their guessing about what would happen, they were using their existing ideas to predict. After that, when they worked in the group, they tested their existing ideas. In the case of Juan and Maria, the experimental evidence did not support their existing idea; however, for Ana, the fact that object A floated was the evidence that supported her existing idea, so it became stronger.

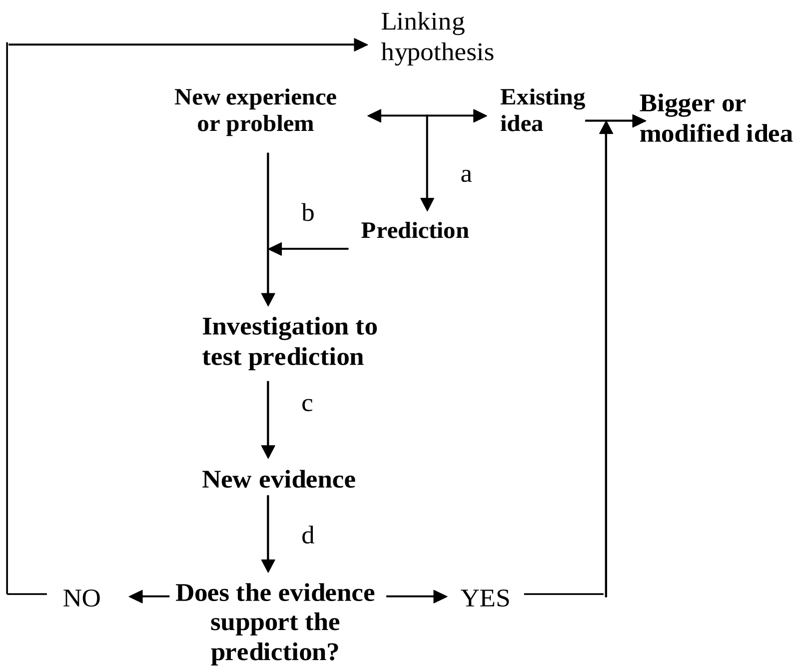

Figure 1. *The constructivist learning model used in some IBSE documents* (Harlen, 2007; Saltiel, 2006)

Besides the purely individual focus, social interactions have been important in the teaching model of IBSE. Children do not only learn by making sense of new experiences on their own, but also in collaboration with others. Social interactions actively develop children's own understanding with the spur of communication with others (e.g. Insight: An Elementary Hands-On Inquiry Science Curriculum, EDC Center for Science Education). For instance, one can imagine that during the test Maria and Juan will have a new hypothesis when talking to Ana and Pablo, due to the experimental evidence. In addition, one can interpret that when Blanca approached Pablo and gave him the object A, she was trying to show him that the properties of the object A could be relevant in order to predict. Or maybe, she wanted to encourage him to use his theory, which she expected to be that the mass of the objects influences the buoyancy.

For some IBSE researchers, assessment for learning is an important tool available to teachers to support students' conceptual change and modification of mental structures. The assumption is that when the students learn in constructivist environments, they experiment the "conceptual change" that will modify their mental structures. For instance, Shavelson et al. (2008) write: "We went beyond the usual definitions of science achievement as largely acquisition of declarative and procedural knowledge and evaluated the claim that formative assessment promotes conceptual change (p.299)… Their justifications and explanations reveal their schematic knowledge (knowing and reasoning why) and become the focus of classroom discussion with the goal of closing the gap in "mental models" for explaining what they saw, based on empirical data" (p.304).

In this approach the justifications and explanations produced by children reveal the thinking process expected; they provide evidence of "conceptual change". Relating back to the story, one could expect Blanca to collect information about the students' mental structure, to later try and stimulate discussions, activities, problems, etc., with the purpose of helping students constructing the idea that "what matters in the buoyancy phenomenon is the density of both the water and the object". The focus of the assessment process is on the explanations that students give during the class and how those explanations become part of the "classroom discussions". Somehow, those justifications and explanations externalize the mental models inside the individual mind. The interactions with external actions or agents will provide some feedback in order to change the structure into a more "adequate" structure. In the assessment for learning model, the role of the teacher is fundamental in eliciting, recognizing and giving feedback (Ruiz-Primo & Furtak, 2006), in order to direct the change process of mental models. The interaction with other learners is also an important mechanism of feedback.

In IBSE assessment models, it is relevant to inquire about the learning process of students in order to judge how far their understanding is from the learning goals. The final objective of the assessment is to take action in order to "close the gap" between stated learning goals and students' externalized justifications and explanations. The learning goals are expressed in terms of science contents, process skills, and attitudes. These elements constitute the knowledge that students are expected to acquire after several activities. The model assumes that, during the informal and formal moments of assessment, the children and the teacher need to share the learning goals so as to know where they are standing in relation to those goals; and in case they are not reaching the goals, to know how to get there.

This view of assessment for learning is what I call the individualistic point of view in assessment for learning (for uses of the term individual point of view in Mathematics and Science Education see Leach & Scoth (2003) and Radford (2008)). Although the teacher and the other students are important in the assessment process, the focus is the learning process happening in the head of the individual student. The conceptual change of each individual student is what matters at the end. The focus points on the individual learning process: skills, contents and attitudes. The significance of "the other" in the learning process is not taking into account.

It is interesting to notice that even though the IBSE teaching model emphasizes the importance of social interaction, assessment is mainly individual. Thus, there appears to be a disjunction between the espoused importance of "others" in the individual learning process in IBSE teaching models and the highly individualistic formulations of assessment. The interpretations that can be made of interactions and conversations in the different spaces promoted in IBSE classrooms seem to be limited in possibilities for acknowledging what may count as "evidence" of learning. In the following section, I will try different interpretations with the support of socio-cultural theories of learning in order to formulate some ideas of socio-cultural views of assessment for learning in IBSE settings.

THE SOCIO-CULTURAL POINT OF VIEW IN IBSE – ASSESSMENT FOR LEARNING

I will start by moving away from the basic assumption that the learning process happens in the head of the individuals. Rather, I assume that learning happens in the social spaces where subjects participate in social activities where cultural products are available for them in complex social and historical setting. According to socio-cultural theories, learning occurs while the subject, a fundamentally social being, participates in socially structured practices (James, 2006; Leach & Scoth, 2003; Radford, 2008). Therefore, I will acknowledge that "learning is by definition a social and collaborative activity in which people develop their thinking together" (James, 2006, p. 57). The core aspects that I will consider in my reflections about assessment for learning in IBSE are how students make sense of a situation in the daily classroom context, and what is the mechanism by which the participants in that situation can share meanings and interpretations of this situation.

For socio-cultural learning theories, "thinking is conducted through actions that alter the situation and the situation changes the thinking; the two constantly interact. Especially important is the notion that learning is a mediated activity in which the cultural artefacts have a crucial role" (James, 2006, p. 57). In that sense, symbols, concepts, cultural ways of talking, historical experiences of the subject and of the society, the historicity and framing of a situation, and the artefacts available in a particular moment guide our perception and the meaning that we are able to make of the different elements involved in a situation. Taking this into consideration, the development of scientific knowledge is not only constrained by empirical data emerging from experiments, but it is also socially validated by the language, the symbols, and the tools that are available in the scientific community in a particular historical moment. In that sense, scientific knowledge cannot be learnt from sensory experience alone (Leach & Scoth, 2003). A classroom community develops with time a shared history that provides the setting in which particular forms of thinking can emerge. Considering the learning of an individual outside of that context and setting is simply not possible.

For instance, the events in the story could be interpreted in another way. One could imagine possible thoughts of Ana, one of Blanca's students, when Blanca asked what would happen to the objects when put into the water. Ana probably recalled when her mother puts potatoes in a pot, and the water in it goes out while she observed the water pouring out of the aquarium when the objects were introduced into it. She may not have thought about the capacity of objects to float or sink. However, when the collective discussion took place and the different possible positions of the objects in the water were represented, she changed her thinking and became aware that she was thinking about another aspect of objects and water. Then, she remembered when her mother told her that when lentils are soaked in water, those that are in the surface have to be removed because they are bad. She may have thought that the same object can be in the bottom or in the surface, depending on how good or bad it is, as in the case of the lentils. So it was very complicated for her to decide where the object would be.

What Ana thought, was mediated by her history of interactions with water and objects in a particular social setting, with particular artefacts and languages available: in the kitchen, in a cooking session, with her mother's language and knowledge. She learned from her mother that there is good and bad lentils and that this may be recognized by the fact that ones float and others sink. At the same time, in another social setting, the classroom, she was learning a new social approximation to the relation between water and objects, helped by the others' experiences in their family, with friends or in that particular social setting. Those different experiences allow her to be aware of different ways of arguing, reasoning and thinking.

In order to move from the individualistic view in assessment to one that takes into account the socio-cultural nature of learning processes, I propose to focus on the learning happening in the diversity of social situations in IBSE classrooms. I will use the different IBSE classroom moments described previously, where learners are engaging with each other in social and physical settings: talking, thinking and doing with others, experimenting with different kinds of objects, using the languages they bring to the situation from out-of school experiences and the new ones that are available, and making sense of the activities they are doing together. I will assume that learning is rooted in the engagement among subjects and is happening in the shared activities, in a particular, socially structured setting. Knowledge is in the spaces of engagement among subjects. Knowledge and learning are not in the head of individuals.

I call *Spaces* of *Learning-in-Otherness* to those spaces that are generated while students and teacher are engaging with each other, in the physical and social setting of each moment of the IBSE classroom. The *Figure 2* shows the diversity of spaces that I recognized. Each space is constituted by *artefacts*, such as notebooks, board, posters, etc.; *semiotic symbols*, such as concepts, diversity of representations, etc. *activities* such as problems, challenges, etc.; *communication* such as body language, verbal language, written language, etc.; *emotions* as happiness, sadness, etc.; *social relationships* such as friendship, power relations, etc. Those spaces are interconnected, and teacher and students move between them during the class time.

			
Learning-in-otherness Own Space	**Shared Learning-in-otherness Own Space**	**Learning-in-otherness Own Group Space**	**Shared Learning-in-otherness Own Group Space**

	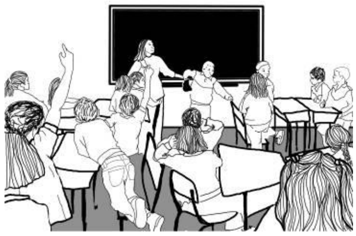	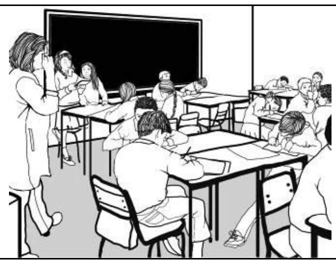
Teacher Learning-in-otherness Own Space	**Learning-in-otherness Collective Space**	**Learning-in-otherness Collective Group Space**

Figure 2. *Representation of Spaces* of *Learning-in-Otherness*

By formulating these spaces, I am trying to focus the attention on the thinking and learning taking place in the moments of engagement among subjects and not in each individual's head. At the same time, I make visible the situatedness of the knowledge that emerges from the activity: while the learners are engaged in writing, reading or looking at the objects in the water, their thinking moves and new possibilities for sense-making emerge.

For example, when Pablo is hesitating about the answer to Blanca's question, his thinking is emerging from the contact with the question, the presence of the objects A and B, and his own experiences in the past. All his thoughts are possible because of all these elements. Somehow, the thoughts are possible in that *Learning-in-otherness Own Space* between his thinking, the answer his writing and the question. At the same time, when Blanca went next to him asking: "what are you thinking?" and he explained that he was not sure about the answer, and then Blanca gave him the object A, another space of thinking (Shared *Learning-in-otherness* Own Space) is there between Pablo's thinking, Blanca's thinking, the object, the question and the notebook. In that way, Pablo had new information that came from the physical setting and the social interaction. For the *Spaces of Learning-in-Otherness*, you can imagine the same complex situation. Somehow, the spaces are interconnected; first, Blanca's question was addressed to all the children. Then, Pablo was thinking alone and writing and following that. After that, Blanca talked to him and gave him the object A. Pablo's thinking and learning evolved in that continuum.

If assessment is what is done in order to help students to learn, and the learning goals are not focused on the learning happening in the children's head, a new perspective for assessment can be thought when the focus is on the *Spaces of Learning-in-Otherness*. Thus, the assessment needs to consider that the students come to the class with a history of interactions with others in their particular cultural world, far from scientific culture. Those experiences mediate the way they see and analyze the activities and situations in the classroom. At the same time, the role of the activities in the collective learning and thinking process will be relevant for the assessment decisions, as well as the characteristics of the thinking and knowledge they are sharing.

Hence, my proposal is to focus the assessment on the *Spaces of Learning-in-Otherness*. In that sense, the assessment will assure that all the participants are making sense and interpreting each situation in a such way that they can be engage in the current activity. The teacher, as the one that knows why the situation is relevant for learning, needs to develop the ability to hear the inquiry thinking that is in those spaces, and make sure that the participants are interpreting the situation in a scientific way. The thinking will be in the notebook of a child, in the poster presented by the group, in the verbal interactions, in the final discussion in the classroom or on the board. Each *Space* of *Learning-in-Otherness* needs to be considered as an opportunity to make the participants aware of what is going on. The way in which the activities, homework, or tests are introduced and used will make the collective process of thinking happen in a different way. Those different opportunities need to be recognized in order to make them closer to the scientific thinking. Since inquiry thinking is not the natural way of thinking in the social settings where the kids normally interact, it is necessary to build bridges between their normal thinking and the new one. Assessment can be thought of as those bridges that the teachers are building day by day.

FINAL REMARKS

I showed that there are different possibilities to approach the assessment for learning in IBSE teaching, depending on the learning theory that is assumed. On one hand, I interpreted one assessment-teaching-learning situation using a constructivist and individualist model of IBSE: learning occurs when learners change their mental structures; modify their own ideas by interacting with the phenomena and during the interaction with other individuals. I argued that in this case, the assessment focus is on the learning process happening in the learners' heads. This will guide the assessment activities. I called that view the *individualistic point of view in IBSE assessment for learning*. In contrast, I interpreted the same assessment-teaching-learning situation from a point of view of socio-cultural learning theories: Learning happens while subjects participate in a social situation where the cultural artefacts and historical social experience of the learners and the teacher allow the participants to make new sense and new meaning to a particular situation. I defined the *Spaces of Learning-in-Otherness* in order to focus the attention of the assessment for learning process on the social spaces of engagement rather than on the students' head. This approach implies a new way of making assessments in the classroom, considering each space as a moment to be aware of the collective thinking that is taking place.

Further reflection has to be made in order to consider a different ways of interpreting assessment activities that have been considered as relevant for learning processes in Inquiry learning contexts. New possibilities for the development of activities in the classroom can be thought. At the same time, the assessment for learning and learning theories exposed are used in a theoretical perspective and not from the perspective of teachers that work in the diversity of cultural contexts where IBSE is growing.

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TOBACCO ADDICTION IN TEXTBOOKS FROM 16 COUNTRIES: PHYSICAL, PSYCHOLOGICAL AND SOCIAL EFFECTS

Graça S. Carvalho
CIEd
Institute of Education
University of Minho
Braga, Portugal
graca@ie.uminho.pt

Artur Gonçalves
Palmeira School Group
and
University of Minho
Braga, Portugal
professorartur@hotmail.com

Catarina Dantas
Externato Carvalho Araújo
Braga, Portugal
catarina.dantas@sapo.pt

ABSTRACT

Smoking is a serious society problem that affects persons physically, psychologically and socially. The textbook is strongly rooted in school education and works like a "screen" that links the space between the pupil and the external reality. It provides pupils with handy information, well structured and systematized contents, in order to facilitate them to build their own learning. In this context, a comparative analysis of the information conveyed by textbooks from the 16 countries was carried out. They differ for their geographical distribution and their historical, political and socio-cultural development: 12 European countries (Germany, Cyprus, Estonia, Finland, France, Hungary, Italy, Lithuania, Malta, Poland, Portugal and Romania), 3 from Africa (Morocco, Mozambique and Senegal) and 1 from the Middle East (Lebanon). Results showed that Morocco is the only country which textbooks do not address the smoking issue. Only 11 countries present the three dimensions of tobacco consumption (physical, psychological and social effects), some omit the psychological dimension, others the social one and others both. The Finnish textbook is the one presenting the smoking issue in a rather balanced way. The results show differences in political, cultural and curriculum with regard to the way textbooks of different countries explore the tobacco problematic.

Keywords: *Health education, smoking prevention, textbooks, cultural diversity.*

INTRODUCTION

Epidemiological studies have confirmed the association between smoke consumption and several diseases such as those of the digestive, urinary, cardiac and respiratory tract as well as oncologic and psychosocial diseases. It is in such a high proportion that today tobacco consumption is the leading cause of illness and avoidable deaths, reducing life expectancy (WHO, 2009). Several international institutions like World Health Organization (WHO), UNICEF, UNESCO, Centers for Disease Control and Prevention in the United States (CDC), International Union for Health Promotion and Health Education (IUHPE) consider political and educational action to be the most powerful instrument for the prevention of smoking abuse prevention (IUHPE, 2008).

Being an essential link between the scientific knowledge selected for teaching (external didactic transposition) and the knowledge effectively taught in the classroom (internal didactic transposition) (Clément, 2006), the textbook works as a teaching instrument transferring cultural references to the school as it reflects the educational policies and the social interests. It is a cultural object that talks about the society in which it is included (Lebrun, 2007).

Although new ways of thinking and modern pedagogy criticize the intellectual bookish/encyclopedic pupils, the fact is that the textbook is considered by teachers, pupils, parents and governmental institutions as a fundamental and structuring instrument of the educational process and so, the most used pedagogical resource at school. Therefore the textbook is still strongly rooted in school education and plays the role of a "screen" that links the space between the pupil and the external reality, therefore becoming the centre of formal knowledge (Giordan, 1999). This gives the teacher an important role as he/she must assign an appropriate position contextualized with the teaching-learning process where the book should provide pupils with handy information, and well structured and systematized contents, in order to facilitate them to build their own learning (Perrenaud, 2005)

Accordingly, and particularly in the problem of tobacco addiction, the textbook can assume the role of a memorandum coordinator of facts and ideas built interactively over a lifetime and during classes, in order to complement the acquired knowledge as well as to provide useful reading and suggestive images. In this way, the textbook can contribute for the prevention of tobacco consumption, as smoking is a serious physical, psychological and social problem of modern society, particularly for children and young people who are more vulnerable (Precioso, 1999; Negreiros, 2000; WHO, 2009).

In this context, a comparative analysis of the information conveyed by textbooks from the 16 countries involved in the European project BIOHEAD-CITIZEN (Carvalho, 2004; Carvalho & Clément, 2007) was carried out, assuming that, overall, they convey the concepts and ideas of the national Health Education programmes (Gonçalves, 2008). The 16 countries involved in this project differ not only for its geographical distribution, but also and mainly by their historical, political and socio-cultural development: 12 European countries (Germany, Cyprus, Estonia, Finland, France, Hungary, Italy, Lithuania, Malta, Poland, Portugal and Romania), 3 African countries (Morocco, Mozambique and Senegal) and 1 of the Middle East (Lebanon).

To establish whether there are different approaches to the problem of smoking addiction and determine whether physical, psychological and social dimensions have identical treatment in textbooks of different countries, the following research question was formulated: Are there significant differences among the textbooks of the 16 countries regarding the way they address the tobacco problem?

METHODOLOGY

For the analysis of textbooks we used the specific part for tobacco of the Health Education grid (Table 1), developed in the FP6 STREP European project BIOHEAD CITIZEN (Carvalho, 2004). The following indicators were analysed: (*i*) physical effects, (*ii*) psychological effects, and (*iii*) social effects, (*iv*) anti-smoking campaigns and (*iv*) environment (Table 1).

These indicators were applied to a total of 76 textbooks where this topic was referred, in primary and secondary school, in the 16 countries involved in the project, distributed as follows: 3 from Cyprus (CY); 5 from Germany (DE); 2 from Estonia (EE) ; 1 from Finland (FI); 6 from France (FR); 5 from Hungary (HU); 11 from Italy (IT); 14 from Lebanon (LB); 2 from Lithuania (LT); 2 from Malta (MT); 7 from Morocco (MO); 2 from Mozambique (MZ); 1 from Poland (PO); 12 from Portugal (PT); 1 from Romania (RO) and 2 from Senegal (SN).

The number of occurrences in relation to the Biomedical model (BM) or the Biopsychosocial model (BPSM) of health were calculated by the occurrences of specific indicators for the BM (pathological, curative and preventive references) and for the BPSM (healthy life, empowerment, environment issues). Similarly, the number of occurrences of physical, psychological and social effects associated to the consumption of tobacco was calculated. Two separated analysis were conducted, one on the textual occurrences and the second on the images.

For each country, the data are the means of the occurrences of each group found (physical, psychological or social effects) in the totality of the analysed textbooks of the country, for either text references or images.

Table 1 - Grid with indicators for the data collection on Tobacco

Conceptions	INDICATORS	IMAGES No. occurrences	TEXT No. occurrences	ANNEX HE-3.2.n
3.1. SMOKING ABUSE	Unhealthy components of tobacco			
	Physical effects in the body: - Respiratory tract - Circulatory system - Nervous system - Fetus disorders (of smoking mother) - Lung cancer - Other diseases			
	Psychological and behavioral effects: - Anxiety - Addiction (dependence) - Others (specify)			
	Family disturbance: - Overspending, - Children's illness - Passive smoking - Mortality rates - Others (specify)			
	Anti-smoking campaign : - Information - Educational action - Legal rules - Promotion of healthy habits - Fear contents - Possible assistance (phone , number, website ...			
	Environmental (and social) approach: - Tobacco factories - Identifying images - Notion of pleasure during consumption			

RESULTS

Health Education in textbooks of 16 countries: Biomedical model (BM) and Biopsychosocial model (BPSM)

Finland is the only country where Health Education is a separate curricular subject. Therefore all pages (100%) of the analysed Finish textbooks were devoted to this issue.

About 55% of the Cypriot textbooks were devoted to Health Education whereas in the textbooks of the remaining 14 countries, this topic was below 30% (Figure 1).

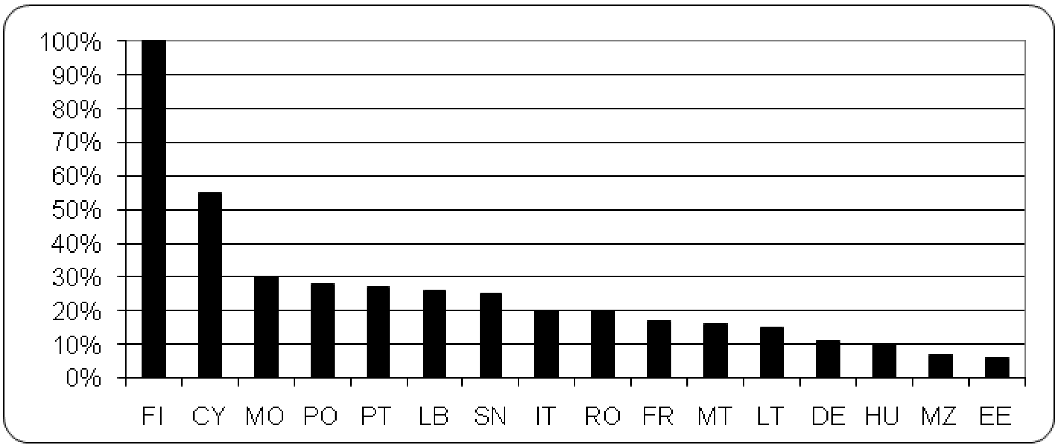

Figure 1- Proportion of the number of pages devoted to health in school textbooks of the 16 countries.

In what concerns tobacco addiction, the biomedical model (BM) of health (characterised by pathological, curative and preventive dimensions) prevails over the Biopsychosocial model (BPSM) of health (characterized by healthy life, empowerment, environment issues) in both textual and iconic elements of textbooks in 14 of the 16 participating countries (Figure 2). In fact, only textbooks books from Finland and Germany are the ones having more occurrences of HP than BM: 67% HP and 33% BM in Finish books and 63% HP and 37% BM in German ones (Figure 2).

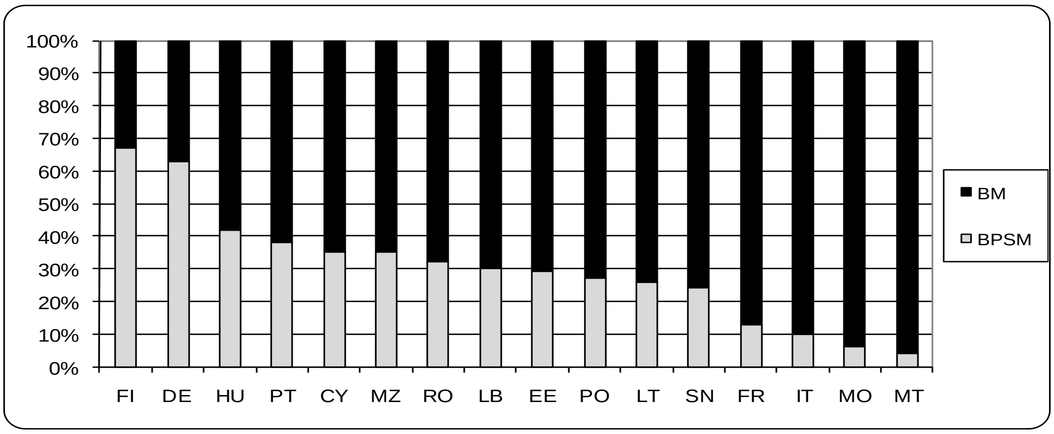

Figure 2- Biomedical Model (BM) and the Biopsychosocial model (BPSM) of health distinguished in textbooks of the 16 countries.

Physical, psychological and social effects of tobacco in textbooks of 16 countries

Text analysis

Finland stands out as the country whose textbooks present more text mentioning physical, psychological and social effects of tobacco (Figure 3). The physical effects of tobacco are the most frequently discussed in the text of all countries textbooks, followed by psychological and social ones (Figures 3 and 4).

Only 11 countries explore the three dimensions of the tobacco problem. The following 6 countries textbooks leave out one, two or the three dimensions of tobacco effects: French textbooks omit the psychological dimension and Lithuanian books the social dimension; Poland and Mozambique do not mention psychological and social dimensions while Moroccan textbooks do not mention any of the three dimensions (Figure 3 and 4).

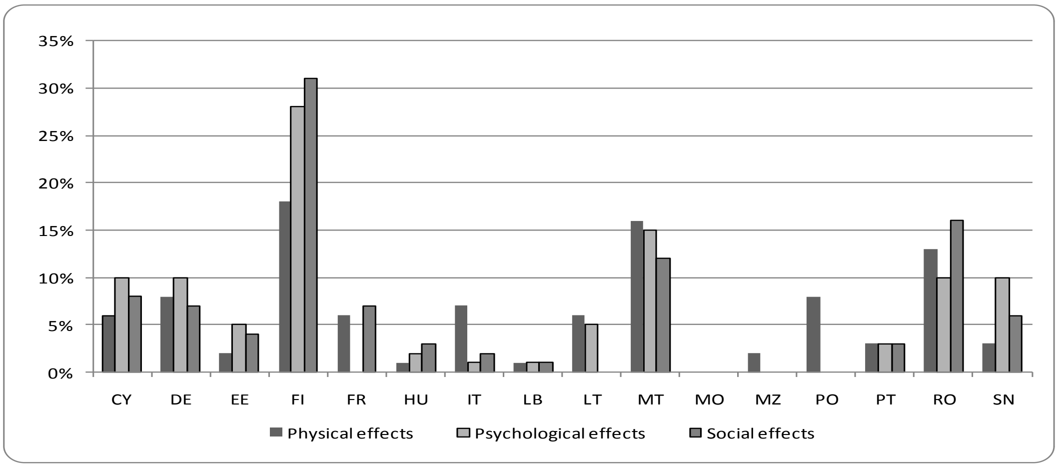

Figure 3- Contribution of each country for the total number of text occurrences of physical, psychological or social effects of tobacco.

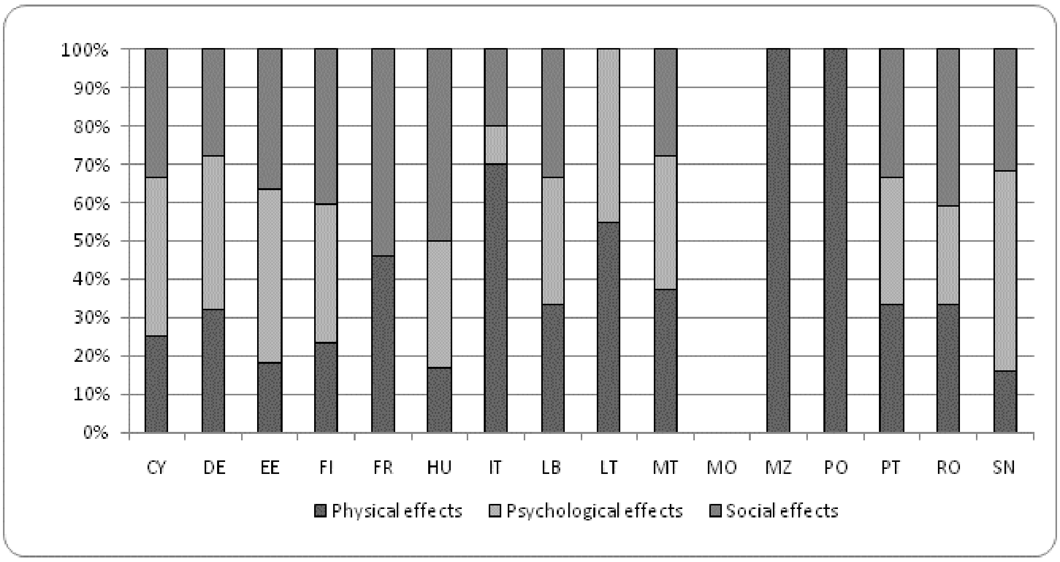

Figure 4- Proportion of text references of physical, psychological and social effects of tobacco in textbooks of each country.

Images analysis

Five of the 16 countries participating in this study (Estonia, Lithuania, Morocco, Mozambique and Poland) do not present images related to physical, psychological or social effects of tobacco and only 6 (Finland, Portugal, Germany, Hungary, Italy and Lebanon) explore the three dimensions of tobacco problem by images (Figure 5). Once again, the Finnish textbook is the one presenting more images related to physical, psychological and social consequences of tobacco consumption (Figure 5).

Despite the large discrepancy in values obtained for the images of physical, psychological or social impact, school textbooks in Germany, Finland and Portugal stand out as those with a better balance between the three dimensions (Figure 5 and 6).

In the case of the Estonian, French, Romanian and Senegalese textbooks, only the physical dimension of tobacco is shown in images (Figures 5 and 6).

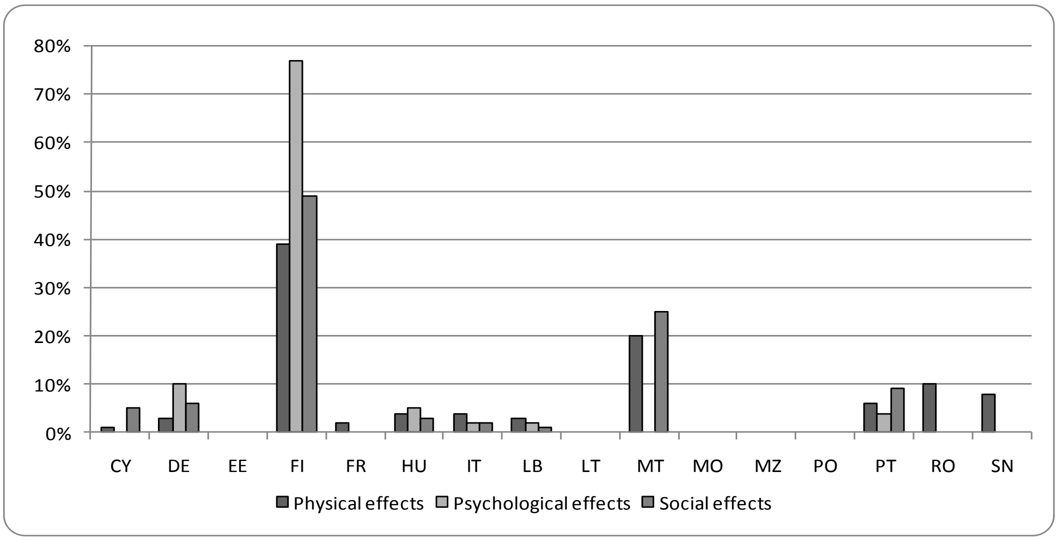

Figure 5- Contribution of each country for the total number of images of physical, psychological or social effects of tobacco.

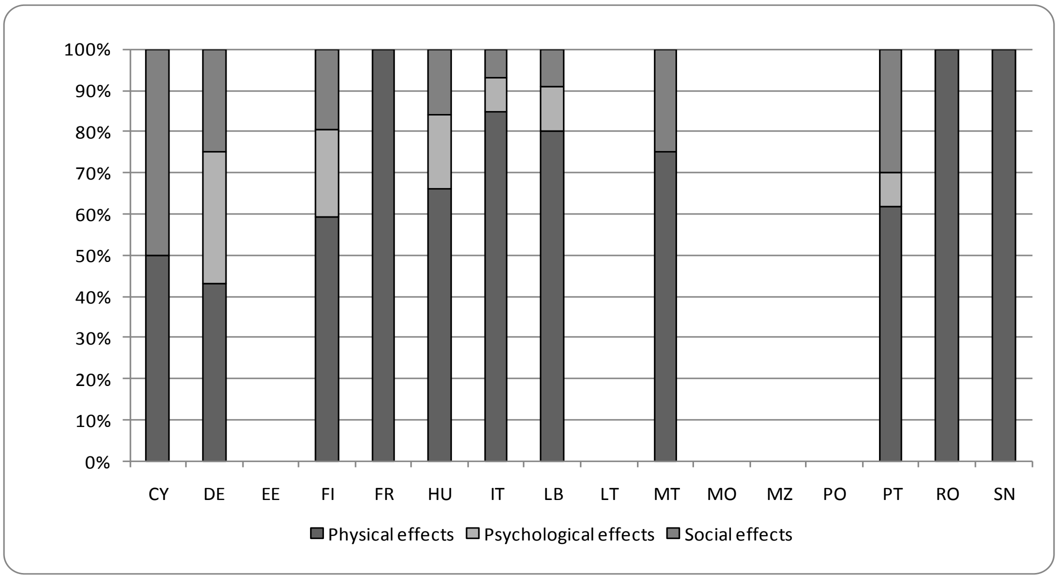

Figure 6- Proportion of images of physical, psychological and social effects of tobacco in textbooks of each country.

Anti-smoking campaigns and environment contexts in textbooks of 16 countries

Only six countries (Germany, Estonia, Finland, Hungary, Lebanon and Portugal) mention in their textbooks anti-smoking campaigns and refer some smoking environment contexts (Figure 7), such as smoking pleasure, smoking groups, tobacco production, tobacco factories, trade legislation, consumption legislation or associations for smoking dependents. Once again the Finnish textbook is the one that presents about 40% of total references to prevention campaigns and 37% of total environment contexts. As for the environments, the texts with more references are the ones from Germany (22%), Estonia (18%), Hungary (15%) and Portugal (5%).

In contrast, the analysed textbooks from France, Lithuania, Morocco, Mozambique and Poland do not incorporate textual references about prevention campaigns nor about the environment related to smoking. Romania, Malta, Cyprus, Senegal and Italy address only the topic of prevention campaigns (Figure 7).

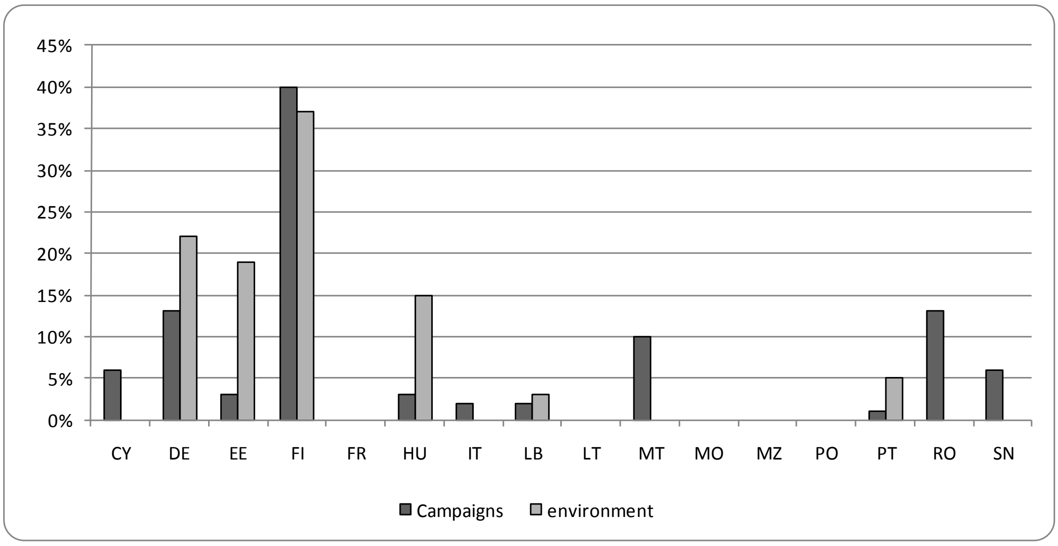

Figure 7- Contribution of each country to the total number of text occurrences of anti-smoking campaigns and environment contexts.

Textbooks from Germany, Finland, France and Portugal present images about anti-smoking campaigns and smoking environment contexts (Figure 8). The Finnish textbook is once more the one with more images from both campaigns (73%) and environments (60%) followed by the Germany textbook for the first issue (11%), France (6%) and Portugal (4%), and for environments the ones from France (20%), Hungary (11%), Germany (6%) and Portugal (3%).

In contrast nine other countries (Cyprus, Estonia, Lithuania, Malta, Morocco, Mozambique, Poland, Romania and Senegal) do not show images concerning both issues (Figure 8). Italian (3%) and Lebanese (2%) textbooks refer only to anti-smoking campaigns while the Hungarian textbooks include only images of smoking environments (12%).

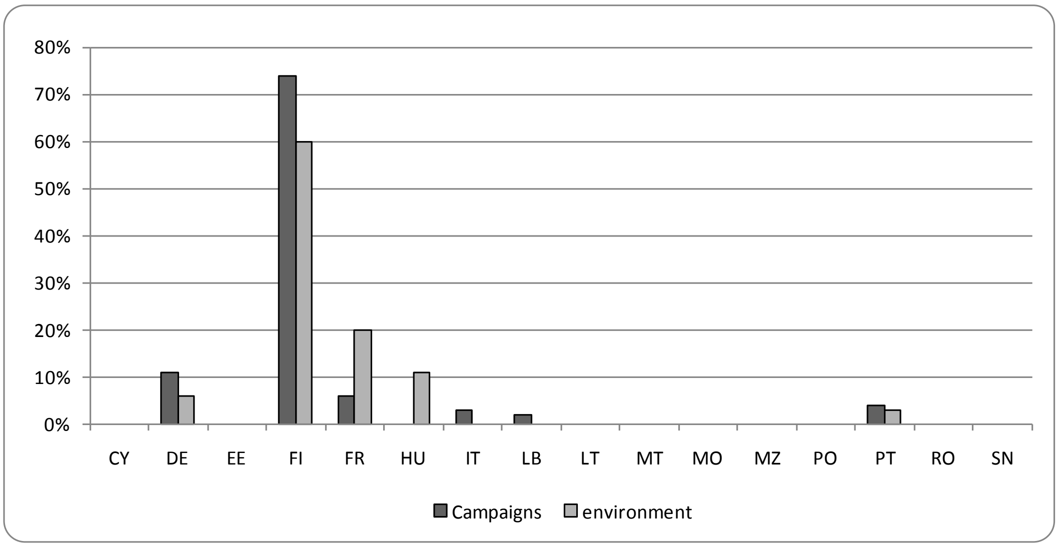

Figure 8 - Contribution of each country for the total number of images of anti-smoking campaigns and environment contexts.

CONCLUSIONS AND DISCUSSION

Of all countries involved in this study, Finland is the only one having a separate curricular subject of Health Education and so the textbook devotes 100% of its content to this subject. The majority of the Finish book as well as the German book (66% and 63%, respectively) express explicitly or implicitly the contemporary Health Promotion view whereas the other countries textbooks are mainly within the classical Biomedical Model. In addition the Finnish textbook is the only one exploring the smoking issue in a rather balanced approach with regard not only to the three health dimensions (physical, psychological and social dimensions) but also to the emphasis given to anti-smoking campaigns and smoking environment contexts.

Morocco is the only country in which textbooks do not address the smoking issue. This may be due to the fact that smoking is a rather common and well accepted male habit in the country.

Of the 15 countries referring to this issue, only 11 countries present the three dimensions of tobacco consumption (physical, psychological and social consequences), some omit the psychological one while others the social one and others both.

In all countries the physical, psychological and social effects of smoking are treated in more detail than the anti-smoking campaigns and smoking environment contexts, in both space (text and image occurrences) and depth of analysis.

In the universe of analysed textbooks only few mention the existence of institutions to help smokers stop smoking. This seems to be a serious gap, since for many pupils the textbook may be the most important source of information they have access to.

The data among the 16 countries indicate that there are different cultural and educational policies in the approach to smoking addiction either in the field of prevention of starting smoking and in the combat for stopping smoking.

On the whole, the present study indicates that the Finnish textbook is the one which presents the smoking issue in a rather balanced way. This study is mainly a quantitative approach therefore a qualitative analysis should be carried out in more detail in order to evaluate whether this Finnish textbook could be taken as an example of good practices regarding the approach to the smoking issue. Therefore it might be considered a model to other countries textbooks, with some adaptations to their specific socio-cultural background.

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DISTRIBUTED COGNITION: SCIENTIFIC INVESTIGATIONS OF PRIMARY SCHOOL STUDENTS IN DUO CONTEXT

Andreas Chiras
University of Cyprus
andchir@cytanet.com.cy

Nicos Valanides
University of Cyprus
nichri@ucy.ac.cy

ABSTRACT
Sixty dyads consisting of two sixth-grade students were instructed to interact with a device and investigate its functioning. The students were explicitly instructed to think aloud prior and after any experiment with the device, to keep a record of their observations and to jointly decide how to proceed with their investigations. At the end of the investigation, each dyad was required to report its final conclusions concerning the functioning of the device. This procedure was based on Klahr and Dunbar's (1988) study, who conceptualized scientific investigation as a dual search, a search in a space of hypotheses and a search in a space of experiments. The results of the study clearly demonstrated primary school students' limitations in terms of cognitive abilities, or in terms of reporting their experimental data and using their records as an external memory system. The results also indicated several factors that contribute or inhibit the functionality of a joint cognitive system in terms of both their social (persons) and material dimensions (the device), and clarified issues relating to distributed cognition.

Keywords: *Distributed cognition, joint cognitive system, scientific investigation*

INTRODUCTION
Traditionally, science education has systematically put emphasis on the mechanistic acquisition and accumulation of content (Valanides, 2003). Science is usually presented as a rigid body of facts, theories, and rules to be memorized and practised, rather than a way of knowing about natural phenomena (Van Driel, Beijaard & Verloop, 2001). Science learning experiences are mostly isolated from everyday life (Reif & Larkin, 1991) and, hence, do not enable students to apply in their personal lives outside the school what they learn in school (AAAS, 1990). Recent reform science documents emphasize the need to bring scientific inquiry experiences into science classrooms (National Research Council, 1996, 2000). Participation in inquiry can help learners acquire scientific reasoning skills, such as, experimentation, formulating questions, making observations, collecting and analyzing data, using logical and critical thinking to formulate conclusions, evaluating alternative explanations, recording and interpreting data, and many others (Zimmerman, 2000, 2005, 2007). These reasoning skills are crucial for the preparation of scientifically-literate citizens who can effectively participate in public discourse and decision-making regarding science-related social issues (American Association for the Advancement of Science, 1990, 1993; Hogan, 2002).

Klahr and Dunbar (1988; Dunbar & Klahr, 1989; Klahr, 2000) considered scientific reasoning as problem solving involving search in two coordinated spaces, the hypothesis space and the experimental space. The hypothesis space represents all possible hypotheses, and the experimental space represents all experiments that can be conducted. Prior knowledge and experimental results guide the search in the hypothesis space, while a current hypothesis guides the search in the experiment space and can lead to the generation of new hypotheses. This model has three basic components: search in the hypothesis space, search in the experimental space, and evaluation evidence. Each component entails different processes with different results. Searching the hypothesis space entails looking for a plausible hypothesis, and results in a particular hypothesis to be tested. Testing this hypothesis entails searching the experiment space for an appropriate experiment, and results in confirmatory or disconfirmatory evidence for that specific hypothesis that provides the grounds for a decision process concerning the acceptance, rejection or modification the hypothesis.

The fundamental assumption of traditional cognitive theory is that cognitive processes are internal processes and the unit of analysis has been always the individual cognitive system. Cognitive psychologists tried to explain how information is represented inside the human cognitive system, and decode the way in which these representations are transformed, combined and processed inside the system (Simon, 1969). Under this framework, the social and cultural context is left out of the analysis.

In contrast, the theory of distributed cognition considers the “joint cognitive system” as the unit of analysis (Hutchins, 1995a, 2005b; Norman, 1993; Pea, 1993; Salomon, 1993). Flor and Hutchins (1991) argued that distributed cognition is devoted to the study of how knowledge is represented both inside the heads of individuals and in the world (environment, culture, social interactions), the transmissions of knowledge between different individuals and artefacts, and the transformations that external structures undergo when acted upon by individuals and artefacts. Studies of group cognition in natural settings indicated that cognitive processes may be distributed among the members of a social group. They may also involve coordination between internal and external (material or environmental) structures. Cognitive processes can also be distributed through time so that the products of earlier events can transform later events (Hollan, Hutchins, & Kirsch, 2000).

In a joint cognitive system, the artefacts and the individuals are considered only as parts of an extended cognitive system that interact to produce cognitive work (Hollnagel & Woods 1983; Woods, Johannesen, Cook, & Sater, 1994; Woods & Roth 1988; Rasmussen, Pejtersen, & Goodstein, 1994). This joint cognitive system is cognitive in the sense that it processes information to execute cognitive tasks. Information processing, however, is not the sum of the operations of two or more independent components. On the contrary, information processing is distributed between the artefacts and the individuals who work together to produce behaviour. Dowell and Long (1998) argued that this cognitive work is simultaneously accomplished by all components of the joint cognitive system and in such away that a change in one of the components of the joint cognitive system has always implications on the distribution of cognitive functions.

Pea (1993) distinguished between two dimensions of distribution of cognition: a social dimension and a material one. The material dimension of the distribution refers to the incorporation of all kinds of mental and physical artifacts in which cognition is encapsulated, while the social dimension of the distribution refers to the involvement of social others who assist by functioning as cognitive resources.

The present study was guided by the Klahr and Dunbar model (1988) and took into account the notions of distributed cognition and joint cognitive system, and attempted to evaluate and compare the performance of the components (social and material) of a distributed cognitive system. The study also focused on the underlying cognitive processes operating when primary school students conduct investigations and on identifying factors that may hinder or support the optimal functioning of a joint cognitive system taking into consideration both its social (students) and material (a device) dimensions.

METHODOLOGY

A sample of 520 sixth-grade students were initially administered the Raven's Progressive Matrices (RPM) and, based on their performance, a smaller sample of 120 students was selected. These students were assigned in 60 dyads, where 20 dyads consisted of students who had high performance on RPM H-H, 20 other dyads consisted of students who had low performance on RPM L-L, and the remaining 20 dyads consisted of one student having high and another student having low performance on RPM H-L. These dyads were instructed to interact with a device and investigate its functioning. The device consisted of a wooden box with eight light bulbs in a line and five switches in another line underneath. The bulbs and the switches were connected in a hidden circuit inside the box, while a red button beneath the switches was to test which lamp(s) was (were) lit on. In the circuit, one of the switches was connected as a general switch, while another switch was a dummy one. The students were explicitly instructed to think aloud prior and after any experiment with the device, and to keep a record of their experiments and the consequent results. The students had to jointly decide how to proceed with their investigations. At the end of the investigation, the students were required to report about their final conclusions concerning the functioning of the device.

Data were collected with observations and think-aloud protocols, as the students were jointly investigating the functioning of the device. Qualitative methods were employed to analyze the interactions among students and between the students and the device. The software ENVIVO was initially used for an in-depth qualitative analysis of the audio-taped think-aloud protocols that were consequently transcribed. The software INSPIRATION was also used for visually representing the kind of interactions and the different thinking elements that the members of each dyad exhibited, as they were attempting to investigate the functioning of the device. These representations in conjunction with the transcribed think-aloud protocols were also used to compare the role and the contribution of the students, as well as the role of the device as a source of data and how it continuously guided students' attempts to understand its functioning.

RESULTS

Each investigation was divided into interaction sequences representing units of dialogue that began when a student formulated a hypothesis, made an observation, proposed an experiment, formulated a prediction etc, and at least one statement from the other student followed the initiating statement. An interaction sequence ended when a student stepped back from the flow of the interaction by posing a new idea that diverted the discussion to a different idea. Every time a new or an alternative hypothesis was formulated or a new experiment was proposed etc, a new interaction sequence began, because these statements always indicated a pulling back from the flow of the dialogue. Based on the interaction sequences, two types of interaction sequences were distinguished: "collaborative" or “competitive.” An interaction sequence was coded as “competitive” when a student initiated something and the other student responded to him by (a) simply agreeing with the statement, (b) passively or neutrally acknowledging the statement, (c) repeating the preceding statement verbatim, (d) expressing a disagreement without justification, and (e) proposing something irrelevant. Within collaborative interaction sequences, both students contributed substantially to the discussion in such away that both students were equally or almost equally responsible for the outcome of the sequence. A coding scheme was thus developed and progressively refined. Then, two independent coders coded 20% of the investigations. The inter-coder reliability (Guba, 1981) between the two coders was 0.84. Disagreements were then resolved through discussion, and one of them completed the coding of the remaining investigations.

The “Degree of Collaboration” for each dyad was then calculated. Operationally, the “Degree of Collaboration” was defined as the number of collaborative interaction sequences, divided by the total number of the interaction sequences in an investigation. The results of the study indicated that the mean of the “Degree of Collaboration” for each dyad was 0.149 (SD= 0.143), which implies that the students spent most of the time during the investigation working competitively. Particularly, the mean of the Degree of Collaboration for H-H dyads was 0.263 (SD= 0.154), for H-L dyads was 0.113 (SD= 0.113), and for L-L dyads was 0.069 (SD= 0.068), respectively. A one-way ANOVA analysis was used to compare the mean of the Degree of Collaboration among the three types of dyads. The results indicated that there was a significant difference in the Degree of Collaboration among the three types of dyads [$F(2, 57)= 15.072$, $p = 0.000$]. Post hoc comparisons using Scheffe test showed that the mean of the Degree of Collaboration for H-H dyads was significantly higher than the mean of the Degree of Collaboration for the other two types of dyads ($p<0.05$). However, there was no significant difference between the mean of the Degree of Collaboration of H-L and L-L dyads. The findings indicated that students in H-H dyads were collaborated in higher degree than those who were paired in L-H and L-L dyads.

Based on the Degree of Collaboration, each investigation was divided in four different stages. In Stage 1 (Initial Investigation), the students worked competitively. During the Initial Investigation three different ways of work were detected: (a) in 35 dyads, the students followed the same way of thought, but without taking into consideration each other’s opinion, (b) in 9 dyads, the students followed a different way of thought, without any effort to investigate how the other was thinking, and (c) the students in 12 dyads used a combination of the two previous ways. Initially, the students followed the same way of thought, but later each one followed his own way of thought, while, at the end, followed the same way of thought.

In Stage 2 (Intermediate Investigation), the students began efforts to collaborate, and to take into consideration each other’s opinion, but, in some cases, they continue to work competitively. Thus, Stage 2 was characterized by an alternation of episodes in which the students collaborated and episodes in which the students worked competitively.

In Stage 3 (Collaborative Investigation), the students managed to collaborate continuously. Thus, they not only took into consideration each other’s opinion, but also took advantage of their "external memory system," and the information that was provided by the device. At the end of investigation, and after the students reported their final conclusions concerning the functioning of the device, the researcher prompted the students to re-examine their data and draw any additional conclusions. This part of the investigation was considered as a fourth and separate stage (Collective Review).

The majority of the investigations (n= 38) included only the stage of Initial Investigation. Ten investigations included two stages (Initial and Intermediate Investigation) and only 12 other investigations included three stages (Initial, Intermediate and Collaborative Investigation). Finally, in 9 out of 60 investigations, the students managed to take advantage of the stage of Collective Review. The majority of H-H dyads (n= 11) included three stages (Initial, Intermediate and Collaborative Investigation), indicating that these students managed to collaborate during the investigation. Besides, three from these dyads took advantage of Collective Review. On the contrary, the vast majority of the H-L (n= 15) and H-H (n= 16) dyads, respectively, included only the stage of Initial Investigation, indicating that these students were working competitively throughout the whole investigation.

Thirty dyads identified the general switch (GS). Especially, 17 H-H dyads, 12 L-H dyads and only one L-L dyad succeeded to identify the general switch. The vast majority of these dyads (n = 25) identified the GS during the Stages 1 and 2. Furthermore, 14 dyads managed to identify the GS by coordinating their hypothesis and collected evidence, while the rest 16 dyads examined the collected evidence to identify the general switch. Only 8 H-H dyads gave the GS the right name and explained how it worked. The remaining dyads supported that the particular switch "is a magic switch which when it is placed on the down position, a bulb is light up," "it is a source of electrical energy, which provides each bulb with an amount of energy to light up" or "it distributes electric energy to all bulbs."

Only 20 dyads identified the "dummy" switch (DS). The majority of these dyads (n= 14) was H-H type. On the contrary, only 6 L-H dyads and none L-L dyad managed to solve the problem of the DS. Only three dyads identified the DS by coordinating their hypothesis with the collected evidence, while 17 dyads identified the DS after examining the collected evidence. Two of these dyads considered that the particular switch played a vital role in the circuit, because "it could make the bulbs light up twice," while 18 dyads comprehended that the particular switch was not connected to the electric circuit and supported that "it doesn't work," "it is usefulness," or "it is dummy one."

The students of 52 dyads preferred to perform experiments that would generate a result or would make a lamp to light on, based on their hypotheses. This tendency is known as confirmation bias (Wason, 1960) or as positive-test strategy (Klayman & Ha, 1987). The remaining 8 dyads employed a negative-test strategy, that is, they performed experiments that could disconfirm their hypotheses. An example of the negative-test strategy was employed by the dyad $H\text{-}H_{11}$:

H_{21}: I think that a bulb always light up, when the switches 1 and 3 are placed on the down position.

H_{22}: I suggest to place the switch 3 on down position and the switch 1 on up position (all the other three switches were placed on up position) to find out if you are right.

H_{21}: I agree.

H_{22}: Let's do it. (After the experiment) Bulb 2 light up. Unfortunately, you were wrong. I conclude that a bulb light up when only the switch 3 (general switch) is placed on down position.

H_{21}: I agree.

In the previous dialogue, student H_{21} formulated the hypothesis that "a bulb always light up, when the switches 1 and 3 are placed on the down position." If the students proceed to test this hypothesis by executing experiments using the positive-test strategy (i.e., DUDUU, DDDUU, DUDDD), (the five letters represent the five switches of the device and U refers to the up position and D refers to the down position), this hypothesis would be confirmed, even though it was wrong, because a bulb would light on since the general switch (switch number 3) was on the down position. The students (H_{21} and H_{22}) executed an experiment that they expected to disconfirm their proposed hypothesis. Thus, they not only rejected this hypothesis, but they also progressed in identifying the GS.

The careful analysis of the investigations showed that students did not take full advantage of the available information. Instead, they chose to take into consideration only the information that was provided by their positive experiments, that is, experiments where a bulb lit up and considered that the negative experiments did not provide any useful and relative information. The students in 17 dyads formed at least a hypothesis with the possibility of a negative experiment. These students were characterized, according to Schauble, Klopfer, and Raghavan (1991), as engineers, because they manipulated variables in order to generate a specific outcome instead of trying to understand how the device functioned.

The deep analysis of the investigations revealed that the students did not take full advantage of their external memory system. Almost all students belonging in H-H dyads (n = 18) and a large proportion of students belonging in H-L dyads (n = 12) took advantage of the experimental results: (a) to identify one or both special switches (general and "dummy" switch), (b) to identify experiments that they had not executed before and, (c) to avoid the execution of repeated experiments. On the contrary, the students in L-L dyads often trusted their memory to obtain the needed information for testing their hypotheses.

In this task, the experimental space consisted of 32 (2^5) possible experiments, which represented all the different combinations that could be generated using the five switches and their two possible positions (up and down). The number of possible experiments could be reduced to 16 experiments if someone knew from the beginning which switch was the general or the "dummy" switch, or the experimental space could be reduced to 8 experiments if someone knew from the beginning both the general and the "dummy" switch. Each dyad conducted a number of experiments during the investigation. The mean number of performed experiments for each dyad was 25.42 (SD= 7.45) experiments. Particularly, the mean number of performed experiments for H-H dyads was 21.10 (SD= 5.29), for H-L dyads was 24.05 (SD= 6.41) and for L-L dyads was 31.10 (SD= 6.89), respectively. A one-way ANOVA, with the number of performed experiments as dependent variable and the type of dyad as independent variable, was performed. The results indicated that there was a significant difference in the number of performed experiments among the three types of dyads [$F(2, 57)= 13.591$, $p= 0.000$]. Scheffe post hoc analysis showed that H-H and L-H dyads performed fewer experiments than L-L dyads ($p<0.05$). However, there was no significant difference between the means of performed experiments of H-L and L-L dyads ($p>0.05$). This finding is justified by the fact that nearly all H-H dyads (n= 19) and a large proportion of (L-H) dyads (n= 12) managed to identify either one or both switches (general and "dummy" switch) which helped them to restrict their experimental space. These dyads also took full advantage of their collected data and avoided to perform identical experiments. On the contrary, L-L dyads performed more experiments, some of them were identical, and the majority of these dyads (n= 19) did not manage to identify the GS and the DS.

In spite the fact that the students recorded their experimental results, almost all dyads performed some identical experiments. Only 8 out of 60 dyads did not perform any identical (repeated) experiment. The average number of identical experiments was 5.07 (SD =4.73). Particularly, the mean number of repeated experiments for H-H dyads was 2.05 (SD= 2.37), for H-L dyads was 3.90 (SD= 3.55) and for L-L dyads was 9.25 (SD= 4.67), respectively. A one-way ANOVA, with the number of repeated experiments as dependent variable and the type of dyad as independent variable, indicated that there was a significant difference in the number of repeated experiments among the three types of dyads [$F(2, 57)= 20.957$, $p= 0.000$]. Scheffe post hoc analysis also indicated that H-H and L-H dyads performed fewer identical experiments than L-L dyads ($p<0.05$), but there was no significant difference between the mean number of identical experiments between H-L and L-L dyads ($p>0.05$).

Dyad's ability to control variables was also examined. A dyad was considered that employed the control of variables strategy when in two successive experiments moved only one switch. For each dyad the percentage of their experimental trials in which the students employed the control of variables strategy was calculated. The results indicated that the dyads used the control of variables on average of 24,6% (SD= 14,0%) of their experimental trials which indicated that students used the control of variables strategy in a small proportion of their experimental trials. Particularly, the mean number of experimental trials in which the students employed the control of variables strategy for H-H dyads was 27,7% (SD= 9,0%), for H-L dyads was 29,6% (SD= 17,96%) and for L-L dyads was 16,4% (SD= 10,4%), respectively. A one-way ANOVA with the control of variables as dependent variable and the type of dyad as independent variable, was performed. The results indicated that there was a significant difference in the control of variables among the three types of dyads [$F(2, 57)= 20.957$, $p= 0.000$]. Post hoc comparisons, using Scheffe criterion, were subsequently performed and revealed that H-H and L-H dyads employed the control of variables strategy in higher proportion of their experimental trials than L-L dyads ($p<0.05$). There was no significant difference between L-L and H-L dyads concerning this variable ($p>0.05$).

Students' ability to move the switches up and down systematically was considered as a measure of their combinatorial reasoning. The students in 16 dyads exhibited limited combinatorial reasoning, because during the experimentation with the device, the students moved the switches up and down randomly. For example, the students of H-H_3 dyad performed the following sequence of experiments: UUUUU, DDDDD, UDUDU, UUDDU, DDDUU, UUDUU, DUDUU, UDDUD, UDDDD, DUDDD. It is obvious that these students did not move the switches up and down in a systematic pattern. The students in 35 dyads exhibited in some degree their combinatorial reasoning and only the students in 9 dyads were able to employ a more developed combinatorial reasoning. For example, the students of H-H_6 dyad, initially, performed a sequence of five experiments in which only one switch was placed on the down position. Then, they performed a sequence of nine experiments that only two switches were in down position (DUDUU, DDUUU, DUUDU, DUUUD, UDUDU, UDDUU, UDUUD, UUDDU, UUDUD), followed by a sequence of five experiments that only three switches were in down position, and finally they performed a sequence of three experiments where only four switches were in the down position.

CONCLUSIONS

The findings of the study clearly indicate that students assigned to H-H and H-L dyads had significantly better performance, in terms of several variables (number of performed experiments, number of repeated experiments and combinatorial reasoning), than students assigned to L-L Besides, there were no significant differences in terms of these variables between students assigned to H-H and H-L dyads. Besides, students assigned to H-H dyads outperformed students assigned to H-L and L-L in terms of identifying the GS and the DS.

Another important conclusion was that the students spent most of the time during the investigation working competitively. Only the students assigned to H-H dyads managed to collaborate, but the collaboration was developed at the end of investigation (stage of Collaborative Investigation). Based on the Degree of Collaboration, each investigation could be divided in four different stages. In Stage 1, the students worked competitively, in Stage 2, the students began efforts to collaborate and to take into consideration each other's opinion, and, in Stage 3, the students managed to have a better and continuous collaboration. At the end of investigation, and after the students reported their final conclusions concerning the functioning of the device, the researcher prompted the students to re-examine their data and draw any additional conclusions. This part of the investigation was considered as a fourth and separate stage. The results indicate that the dyads were not functioning effectively, since, for the most part, only one of the two students in each dyad was actively engaged in the learning activity, whereas the other student seemed to be a passive observer.

The results of the study also demonstrate that primary school students have limitations in terms of several cognitive abilities. The students in a number of dyads managed to solve the problem, but they faced a lot of difficulties during their investigation. Many dyads exhibited an overall difficulty with dropping an initial hypothesis and stating an alternative hypothesis. Some dyads insisted till the end of their investigation that they could light up simultaneously either all the bulbs or multiple bulbs. Furthermore, they were not able to state or adapt hypotheses on the basis of data gathered or to verify their hypotheses based on contradictory evidence. Many dyads were prone to confirmation bias, that is, they tended to search exclusively for confirmatory evidence, while ignoring discrepant evidence, and failed to revise their hypothesis even in the presence of strong non-confirming evidence. Besides, the vast majority of dyads considered that the information provided by the negative experiments was not useful for their investigation. A lot of dyads did not take full advantage of their external memory system and performed some repeated experiments or redundant experiments. Almost all dyads used the control of variables strategy in a small proportion of their experimental trials and tended to vary too many variables (switches) over experiments, making the interpretation of outcomes virtually impossible. Also, their combinatorial reasoning was not fully developed, since they did not move the switches systematically.

The declared objectives of elementary science education curriculum in Cyprus is the acquisition of science process skills and the dominant teaching practice is the collaborative learning (Cyprus Ministry of Education and Culture, 1994). The total results of the present study suggest that the existing science curricula failed to achieve the ***declared objectives of science teaching. Zimmerman (2005) stressed the need to*** incorporate more authentic features and numerous composite skills in science teaching. Chinn and Malhotra (2001) argued that if schools do not focus on these features, then the cognitive processes developed will be very different from those used in real inquiry and antithetical to that of authentic science.

Additional research efforts will be needed to determine in what order such skills can be mastered, and which early acquisitions are most effective at supporting the development of subsequent acquisitions. Valanides and Angeli (2008) proposed that more research evidence is also needed to produce a more accurate picture of collaborative inquiry using more or less authentic scenarios, so that the role of communication and the inquiry processes at the level of a cognitive system are clearly highlighted.

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THE EFFECTS OF THE PROBLEM BASED LEARNING APPROACH ON HIGHER ORDER THINKING SKILLS IN ELEMENTARY SCIENCE EDUCATION

Derya Cinar

Selcuk University, TURKEY

Sule Bayraktar

Selcuk University, TURKEY

ABSTRACT

This study was conducted to investigate the effects of problem-based learning approach in elementary science education on students' higher order thinking skills. The study was conducted on 6th grade students from an elementary school in Konya, Turkey in the second semester of 2005-2006 educational year. According to Science achievement test that was done before the application two equal classes were selected. While problem-based learning was implemented in one class, traditional methods were implemented in the other. The study was designed according to the pretest-posttest with control group model. An achievement test prepared in accordance with target behaviors of the chapter entitled "Static Electricity" in the unit "Electricity Guiding Our Life" in Science and Technology course was used as testing tool. The test was administered to the experimental and control groups as pretest and posttest. Data obtained after an application that lasted 6 weeks were analyzed by using t-test. Results showed that, problem based learning was more effective than traditional instruction in student achievement in comprehension level. Furthermore, problem based learning was found to be more successful than traditional instruction in improving problem solving and science process skills.

Keywords: *Elementary Science Education, Problem-based Learning, Higher-order thinking skills*.

INTRODUCTION

Problem Based Learning (PBL) aims specifically at improving problem solving and comprehension skills. This approach introduces people with various problems which they are likely to encounter in real life and the principles of solving those problems. PBL enables people to develop a high level of understanding on the subject by solving the problems related to the subjects (Copland, 2000: 535). Problem based learning has been shown to improve the analysis, synthesis and lifelong learning skills (Harland, 2002).

Finkle and Torp define problem based learning as a process that make people face with ill defined problems which reflect real-life problems. PBL engages problem solvers actively by giving them responsibility of their own learning and consequently it develops problem solving skills as well as basic skills (Stepien et al., 1993: 340). Problem based learning motivates students to define the problem, search for the concepts and cooperative learning. It improves communication skills, and supports a powerful classroom learning process which uses real-life problems (Duch et al., 2001).PBL requires people work with a group or a team, cope with different situations, improves self learning and self evaluation skills and motivates people to practice these skills (Woods 1996).

Lehtinen (2002) identifies the steps which are required for implementing the PBL as following: a) Clarifying concepts b)defining the problem and listing the concepts which need to be learned c) Brainstorming d) systematic classification d) formulating the learning objectives e) Lectures and self study f) clearing up g) Reporting

Studies showed that PBL is more effective in increasing students' academic achievement, as well as allowing them to work in groups and construct their knowledge through social negotiation compared to traditional teaching methods (Polanco et al., 2004; Sungur et al.,2006; Goodnough, 2003). Problem based learning is highly appropriate for realizing the aims of science education. Problem based learning might be an effective way of promoting science learning, which is highly related to real life and requires students to possess high level of critical thinking skills. In fact, many science educators investigated the effects of PBL in science education (Treagust & Peterson, 1998; Greenwald, 2000; Şenocak, 2005; Wilson, 2005; Kılıç, 2006). The purpose of the present study is to investigate the effectiveness of PBL in 6th grade students' higher order thinking skills such as comprehension, problem solving, and science process skills.

METHOD

The study was designed according to the pretest-posttest with control group model, which is one of the true experimental models. The study was conducted with 6th grade elementary school students. According to Science achievement test that was done before the application, two equal classes were selected. While problem-based learning was implemented in one class by the researcher, the traditional methods were implemented in the other by the teacher.

An achievement test prepared in accordance with objectives of the topic entitled "Static Electricity" in the instructional unit "Electricity Guiding Our Life" in the science and technology course was used as testing tools. These testing tools were administered to the experimental and control groups as pretest and posttest. The data obtained after an application that lasted 6 weeks were analyzed. For analyzing the data, t-test has been used.

Sample

The sample of this study consisted of two separate 6th grade classroom students from an elementary school in city of Konya which is located in Turkey. The two classes had similar socioeconomic backgrounds, similar curriculum implemented and same topics covered in both classes. Experimental group consisted of 31 students and control group consisted of 30 students.

Variables:

Independent variables: Independent variable is the instructional methods. Experimental group utilized problem based learning and control group utilized traditional instruction.

Dependent Variable: Higher order thinking skills

Instruments:

Science Achievement test

In order to collect data for he dependent variable which was investigated in the study, an achievement test was developed, pilot tested and administered. The objectives of the lessons related to the topics in "Static Electricity" which was covered in the" Electricity Guiding Our Life" unit were determined. The objectives or each lesson in the topic "Static

Electricity” were identified at a table to ensure content validity of the achievement test items. In accord with this table, 37 questions were prepared to test the higher order thinking skills of the students. The questions were investigated by science teachers and experts in the area of assessment and evaluation and some revisions were made based on their suggestions.

37-item pilot test was administered to one hundred and twenty 7th grade students. Based on the data, reliability constant (KR-20) of the test and discrimination indices of the each item were computed. The items which have item discrimination index under 0.30 were eliminated form the test. Based on the analyses, final test was consisted of 30 items and the reliability constant was found to be 0.74. The test was consisted of items which were accessing *comprehension* (10), *problem solving* (10) and *science process skills* (10).

Analysis of Data

The statistical techniques used to analyze the data were means, Standard deviations and t-test. The Data were analyzed by using statistical software SPSS.

RESULTS

Pre-test Results

Table 1. Comparison of experimental and control group for difference in comprehension level of learning on pre-test

GROUPS	N	$\bar{X}$	Ss	t	p
Control Group	30	2,97	1,75	1,872	0,066
Experimental Group	31	2,26	1,15		

Table 1 shows that pre-test scores on comprehension part of the test is 2.97, while it is 2.26 for problem based learning group. The t- test result indicates that there is not a significant difference in terms of comprehension at 0.05 significance level.

Table 2. Comparison of experimental and control group for difference in problem solving skills on pre-test

GROUPS	N	$\bar{X}$	Ss	t	p
Control Group	30	2,90	2,02	1,232	0,223
Experimental Group	31	2,32	1,62		

Table 2 shows that the mean score for control group students is 2.90 and 2.32 for experimental group students in the problem solving skills part of the test. t-test result indicates that the difference is not significant at 0.05 level. The result suggests that there is no difference in problem solving abilities of the two group students.

Table 3. Comparison of experimental and control group for difference in science process skills on pre-test

GROUPS	N	$\bar{X}$	Ss	t	p
Control Group	30	2,5	1,46	3,939	0,000
Experimental Group	31	1,13	1,26		

Table 3 shows pre-test scores of students on science process skills. Science process skill scores for traditional instruction group is 2.5 and for problem based instruction group it is 1,13. t-test result shows a significant difference at 0.05 level. Control group students' science process skills were found to be more improved compared to experimental group students.

Post-test Results

Table 4. Comparison of experimental and control group for difference in comprehension level of learning on post-test

GROUPS	N	$\bar{X}$	Ss	t	p
Control Group	30	4,7	2,17	-6,903	0,000
Experimental Group	31	7,87	1,34		

Table 4 shows the comprehension level mean scores of the students in control and experimental groups. Mean scores on the comprehension test is 4.7 and 7.87 for control and experimental group respectively. T-test result indicates that the difference is significant at 0.05 level. It can be said that the problem based learning is more effective on students' comprehension level.

Table 5. Comparison of experimental and control group for difference in problem solving skills on post-test

GROUPS	N	$\bar{X}$	Ss	t	p
Control Group	30	5,87	2,06	-4,567	0,000
Experimental Groups	31	7,81	1,14		

Table 5 shows that problem solving ability mean score of the control group students is 5.87 and for the experimental group it is 7.81. t-test result indicates that the difference is significant at 0.5 level. This result suggest that problem based learning is more effective than traditional instruction in improving problem solving ability.

Table 6: Comparison of experimental and control group for difference in science process skills on post-test

Groups	N	$\bar{X}$	Ss	t	p
Control group	30	4,43	1,28	-13,092	0,000
Experimental group	31	8,19	0,95		

Table 6 shows that the mean score on the science process skills is 4.43 for control group and 8.19 for experimental groups. T-test result indicates that the difference is significant at 0.05 level. The result suggest that problem based learning is more effective than the traditional instruction in improving science process skills.

DISCUSSION AND CONCLUSIONS

The results of this study is summarized and discussed in the following section. Based on the analyses of the data the following findings were obtained.

1) There was not a statistically significant difference in the scores related to comprehension level of the learning skills between the students taught by traditional and problem based learning in the pre-test. Control and experimental groups were equivalent. However, the mean score of the control group was higher than that of experimental group.

2) There were no statistical differences in problem solving skills and the science process skills of the two groups based on the pre-test results. However, the mean score on the science process skills of the control group was higher than the experimental group.

3) There were significant differences in comprehension, problem solving and science process skills of the control and experimental group. The students utilizing problem based learning method had higher scores on comprehension, problem solving and science process skills scores than the control group students. According to the results of the study problem based learning seems to be more effective than the traditional instruction to increase students' cognitive outcomes.

4) A statistically significant difference is found between the mean scores on the problem solving ability and science process skills test of the control and experimental group. The study results revealed that problem based learning might be more effective than the traditional instruction in improving these skills.

Problem-based learning applications resulted in improvements in all level of learning outcomes namely comprehension, problem solving skills and science process skills. In control group, classifications, definitions and rules directly given to the students and their getting used to traditional instruction could be the reason of the increase in their scores. However, the increase in experimental group's score is higher than the control group's score. Experimental group students learn the lesson by scenarios, made connections with the real life problems, used inquiry and investigative activities, and tried to acquire the objectives of the lesson by using higher order thinking skills. As a result these activities their skills in comprehension, science process skills and problem solving skills have increased more than the traditional group students. During the experimental application, problem based learning group students stated the problems with their own words which made them aware of the lesson objectives and resulted in success in all cognitive objectives.

Some researchers stated that traditional instruction is not effective in improving students' performance since it does not cover the higher order thinking skills (Greening, 1998;

Stattenfield & Evans, 1996; Chang, 2001, Yaman, 2003). Students in experimental group had higher scores in problem solving ability part of the post-test could be related to the fact that they learned their lessons by solving problems. In the intervention period they learned the concepts by searching the problem subject, gained the skills during their lessons and their cognitive skills were developed when they were solving the problems. In problem based learning students should analyze nature of the problem and the problem situation truly to be able to solve the problem. Experimental group students tried to solve the problem by brainstorming, and discussing the why and what questions with their group mates. In static electric subject, problem based learning approach enabled students to think broadly and deeply, improved their inquiry skills and consequently improved their problem solving ability.

oblem solving process requires following steps such as identifying the problem, formulizing the problem, generating alternative solutions, and evaluating the results. In problem based learning students identify the problem, identify what they already know, what they need to know, what materials they need, and what they need to do with their team mates cooperatively. Such activities show similarities with the steps of problem solving ability. Fort his reason students become more effective and acquire expertise in problem solving. Other studies (e.g., Banta et al, 2000; Kaasbøll, 1998; Kwan ve Ko, 1999; McDermott et al., 2000; McDonald, 2002; Orrill, 2002; Perrenet, 2000) also reported improved problem solving skills of the students who utilize problem based learning approach. These studies associated the improvement with students' struggle to cope with the difficulties.

On the other hand, science education includes many other complex skills within the science process skills which include observation, identifying the problem, formulating the hypothesis, identifying the research problem, designing the experiment to test the hypothesis, doing the experiment, collecting data and analyzing data, generalize the results. The reason why experimental group students showed more improvement in their science process skill levels might be related to their applying these steps. Problem based learning, by making students active, acquiring them responsibility of their own learning, using inquiry practices, and enable them to find out the relationships between concepts, improved the science process skills level of experimental group students. Actually, every student has these science process skills. However, these skills need to be used to be improved. By improving science process skills, experimental group students' problem solving skills improved as well. They become more able to think critically and make connections with real life problems.

Problem based learning approach requires using many of the science process skills effectively as well as problem solving skills. Activity dimension of the problem based approach contributes to developing and improving skills related to scientific processes.

SUGGESTIONS

1) Problem based learning requires material usage in a large extent. For this reason, science classes and the laboratories should be supplied with the necessary materials and equipment.

2) Problem based learning requires in class and out of class activities. The parents should be informed about PBL is important for the success of the approach.

3) Creating a school atmosphere which is suitable with PBL approach is important for practicing the method. Support from the other disciplines' teachers, school administrators, and science teachers' to the PBL practices is important since it is an interdisciplinary approach. Consciousness about this approach should be developed in school personnel.

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THE DEVELOPMENT, IMPLEMENTATION AND EVALUATION OF AN INTENSIVE SYSTEM-WIDE PROFESSIONAL LEARNING PROGRAM FOR PRIMARY SCIENCE TEACHERS

Deborah Corrigan **Richard Gunstone** **Rebecca Cooper**

Centre for Science, Mathematics and Technology Education, Monash University, Australia

deborah.corrigan@education.monash.edu.au

ABSTRACT

An intensive 3 day professional leaning program for primary teachers of science was designed, implemented and evaluated. Design foci included concerns with increasing both teacher confidence in and knowledge of science, recognition and appropriate use of the pedagogical expertise of primary teachers, and 6 specific areas of practice (How students learn science, Teaching for understanding in science, Understanding and teaching the nature of science, Engaging students in contemporary science, Planning the science curriculum, Assessing understanding in science). In the 2-4 week gap between days 2 and 3 of the program participants undertook some form of change in their science classrooms and reported on this to day 3 of the program. A range of forms of evaluation data were collected. Examples are: pre- and post-program on-line surveys, a set of open questions used as part of the learning experiences in day 3, the nature of the change projects undertaken and reported by participants, reflections by those teaching the professional learning program, open-ended evaluation questions given in differing forms to different cohorts in the program. The paper considers these data and the ways the data relate to the design and delivery of the program.

Keywords: *curriculum development, curriculum reform science teaching, science learning, professional learning*

INTRODUCTION

The government of the state of Victoria (Australia), as part of its responsibilities for primary and secondary schooling, has an explicit policy focus on increasing student engagement with science and mathematics and improving learning outcomes in these curriculum areas. Through the Department of Education and Early Childhood Development (DEECD) it also has clear policy directions to provide appropriate resources (including professional learning opportunities) for teachers to pursue these priorities. It is in this broader context of ongoing foci on science education and professional learning that the work to develop, implement and evaluate a system-wide professional learning program for elementary science teachers was contracted to the Science Education Research Group at Monash University. This paper will outline the development and implementation of this program by members of the Monash Science Education Research Group, and then consider the consequences of the program (evaluations of the program) and ways these consequences might relate to aspects of the development and implementation features as well as teachers' responses as a result of the government priorities.

THE DESİGN AND İMPLEMENTATİON OF THE PROGRAM

DEECD defined multiple intentions for this program *Primary Science Matters: Professional Learning in Primary Science.* It required:

- the professional learning program to build teacher capacity to improve student learning outcomes in science,
- the provision of support for primary teachers in implementing the science domain of the current Victorian curriculum guidelines,
- emphasis on the key messages of existing science support materials and in particular an on-line teacher resource *Science Continuum P-10* (http://www.education.vic.gov.au/studentlearning/teachingresources/science/scicontinuum/default.htm) that supports teachers of students ages 5-15, (Corrigan et al. 2009), and a comprehensive set of materials combining science and literacy, *Primary Connections*, see Hackling et al. 2007), and
- consistency with other relevant policy and practice from DEECD such as a set of *Principles of Effective Professional Learning* and a new *E^5 Instructional Model* for conceptualising learning and teaching based on the 5Es model developed by BSCS,
- the building of the educational leadership capacity of primary teachers in the area of science" and address the following areas of teacher practice: How students learn science, Teaching for understanding in science, Understanding and teaching the nature of science, Engaging students in contemporary science, Planning the science curriculum, Assessing understanding in science. In considering building the educational leadership capacity in science through these six ideas the program needed to address these ideas "with reference to a particular science curriculum focus, thus building both pedagogical content knowledge and discipline knowledge of participants."

The program was to include an online resource to support learning during the program and to be of 3 days duration in a 'sandwich' structure of an initial 2 days and a later single day, to allow teacher research and development activity between Days 2 and 3. Implementation of the program was to be in cohorts of up to 20, by regions; there are nine such regions in Victoria.

AN OUTLINE OF THE GROUP RESPONSIBLE FOR THE PROGRAM

The Monash Science Education Research Group (referred to as the Monash group) is a highly experienced team of some twelve science educators of high local, national and international reputation. The group is committed to bridging the gap between theory and practice in the work it undertakes such as in the Science Teaching and Learning (STaL) program to develop the science capability of teachers, both primary and secondary (see Berry and Loughran, 2010; Loughran et al, in press); Loughran and Berry, 2006, 2007, 2008; Berry and Keast, 2009, 2010).

In working with teachers, an important strength of the Monash group is to support these teachers to be researchers. In this way, teachers develop knowledge and skills that will place them in positions to make pedagogical choices based on evidence they have gathered through researching their own practice, the learning environment in their own classrooms and schools, and through monitoring the learning outcomes of their students. This approach to research work places the teacher in the position to make informed choices, based on their own learning, about how to maximize the learning opportunities for their students. In order to achieve such a professional learning experience for teachers a variety of approaches have been adopted. Some examples include:

- providing intensive face-to-face workshops for participants to develop a collegiate group, providing some substantive theoretical bases from which to work, and to collaboratively set some learning goals for research back in their schools (see Corrigan et al, 2008; Cooper, 2008; Keast and Berry, 2008),

- meeting the needs of teachers, while giving them a voice to contribute to the science education research literature and providing teachers access to expertise in discipline knowledge, teacher research capability and sources of innovative practice (see Corrigan and Gunstone, 2009, 2010;Loughran et al, 2009; Berry et al, 2008; Corrigan, 2008; Loughran and Penna, 1999; Loughran et al, 2006; Gunstone et al, 2005; Corrigan and Gunstone, 2007),
- providing opportunities for real change in classroom practice by working with teachers developing innovative and sophisticated practice that build ways of identifying, framing, representing and re-representing such practice as well as the teacher knowledge that lies behind this is a critical expertise. Related to this is our passionate belief in the importance of teacher knowledge and teacher research, not only for the profession, but for the more general field of educational research.
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The development and implementation of the program

Both the extensive previous experience of the Monash group and strong awareness of a substantive relevant research and development literature pointed to two issues that are consistently fundamental to primary science teaching across contexts (including cultural contexts, and time). Primary teachers often lack confidence to teach science, and often have poor conceptual understandings of the science they are expected teach, particularly for concepts other than biological. Matters of teacher confidence and conceptual understanding were then constant fundamentals that influenced development and implementation throughout the program, and were also of course prominent aspects of the evaluations that were undertaken.

Also fundamental to the design of the program was the emphasis on professional learning, where the expectation was on each participant being part of a buddy pair that would be responsible for undertaking a small action research project back in their own schools betweens Days 2 and 3.

The development process began with a small group meeting to consider broad sequencing of sessions, across the first two days in particular as Day 3 was clearly understood to be about sharing what participants had done as the action research projects in their schools since Day 2, and using these experiences to develop greater understanding of change, planning and support. A sequencing of topics for the two days and a brief summary of focus in each was generated, and used to gain feedback from a wider Monash group. Then, with four sessions per day for the two days, each session was given authors and they developed a first draft of detail. As each session evolved there were meetings to inform and gain critiques with the broader Monash group, with experienced primary teachers who were to be part of the implementation team and with DEECD staff. A substantial number of presenters needed to be used in the delivery of the program so the sessions were prepared in considerable detail.

Each session was presented in final form with the same broad structure: a summary description and list of session activities and suggested broad time allocation; a statement of intended session outcomes; a list of required resources and materials; and then the detail of each activity. The activity detail indicated what both presenters and participants were intended to be doing, where and how the provided resources were intended to be used, suggestions of links and/or possible difficulties to expect, links to other resources, and a summary indication of what links might be emphasized to (a) the relevant curriculum guidelines, (b) the resources *Science Continuum P-10* and *Primary Connections*, (c) the E^5 instructional model and (d) assessment matters. The Day 3 session detail was developed after a number of the Day 1 and 2 programs had been conducted, so as to reflect the substance of those experiences.

Pairs of presenters implemented each program, one from the Monash group and one an experienced primary science teacher, with, the same pair conducting all three days for each cohort. Individual presenters worked with between one and four cohorts. For each cohort, presenters were provided with a suitcase containing all materials required, and a memory stick with electronic copies of all materials including powerpoints and some video materials.

Recruitment of participants was the responsibility of DEECD. Pairs of participants from one school were strongly encouraged due to the nature of the professional learning participants were to engage in. As participants enrolled in the program they were asked to complete an on-line pre-program survey. This was an important beginning to the program as presenters were committed to learning about the cohorts they were to work with and tailor the program to met the needs and experience levels of participants. On completion of Day 3 all were asked to complete a very similar post-program on-line survey. The professional learning program was undertaken across the nine regions of Victoria during March – June 2009. Details of this program can be accessed at http://www.education.vic.gov.au/studentlearning/teachingresources/science/priscimatters/default.htm.

The consequences of the program

There are a number of forms of data of relevance to informing us of the consequences of the program. Examples include the frequency and forms of activity brought back to each cohort for the Day 3 sessions, some extensive written reflections on the program and the Day 3 consequences by individual presenters, and open-ended evaluation questionnaires administered to cohorts at individual level by regional DEECD staff. All these will be addressed. The focus in this proposal is on three data sources that are most comprehensive and more amenable to summary. The first form of data are the results of a pre- and post-program on-line questionnaire designed to provide some insights into participants' perceptions on the teaching and learning of science, their own levels of understanding in science and their expertise to teach science, both before and after the program. The second set of data are representations of the reflections that were collected throughout the program, with particular attention to participants views on science, while the final data set are responses to a set of six questions that were used with all cohorts as part of the learning experiences on Day 3 of the program.

Pre-program and post-program on-line surveys

The pre- and post survey instruments were similar in many respects, particularly with regard to the six areas of focus for the program, namely How students learn, Teaching for understanding in science, Understanding and teaching the nature of science, Engaging students in contemporary science, Planning the science curriculum and Assessing understanding in science. In addition, confidence in both the primary teachers' understanding of science concepts across a range of year levels and their capacity to act as a leader in science within their school were also a focus of these instruments. They also differed in some important aspects as the pre-survey also focussed on gaining clarity for the presenters around who are the cohort and what background and experience do they bring to the program. This highlights a strong constructivist perspective underpinning this program. The post survey focused more on reflective elements of how participants responded to the program. This highlights a strong emphasis on a formal reflection process as a mechanism for articulating your learning that was also a fundamental underpinning of the program.

Of the more than 200 participants who attended the program from all nine regions, 196 completed the online pre-survey. The majority (76%) were classroom teachers, with 77% of participants being female. Approximately 30% of participants had studied science to Year 12, with 28% having only studied science to Year 10. A smaller percentage had studied science at a tertiary level (1 year – 7%, 2 years – 4%, 3 years – 11% and 4 years – 13%). Many

(33%) participants had more than 21 years teaching experience, with 25% having between 2 and 5 years experience, 19% between 6 and 10 years and 17% having between 11 and 20 years. There were 6% of participants in their first year of teaching.

The participants' pre and post program survey results showed some significant shifts. For example participants identified the Science Continuum P-10, Primary Connections, Victorian Curriculum Guidelines and the E^5 as resources they would make much greater use of to teach science in the future. The post program evaluation data appears to strongly support that the program was successful in meeting its intended aims. As indicated in Figure 1, the program appeared to address the 6 areas indentified in the program design.

Figure 1 gives the overall rating average where the maximum rating is 4.0. With no area rating less than 3.0, it appears from participants' responses that all six areas have been addressed, particularly engaging students in contemporary science. The ratings are based on responses ranging from not addressed, addressed to some extent, addressed well, to addressed very well.

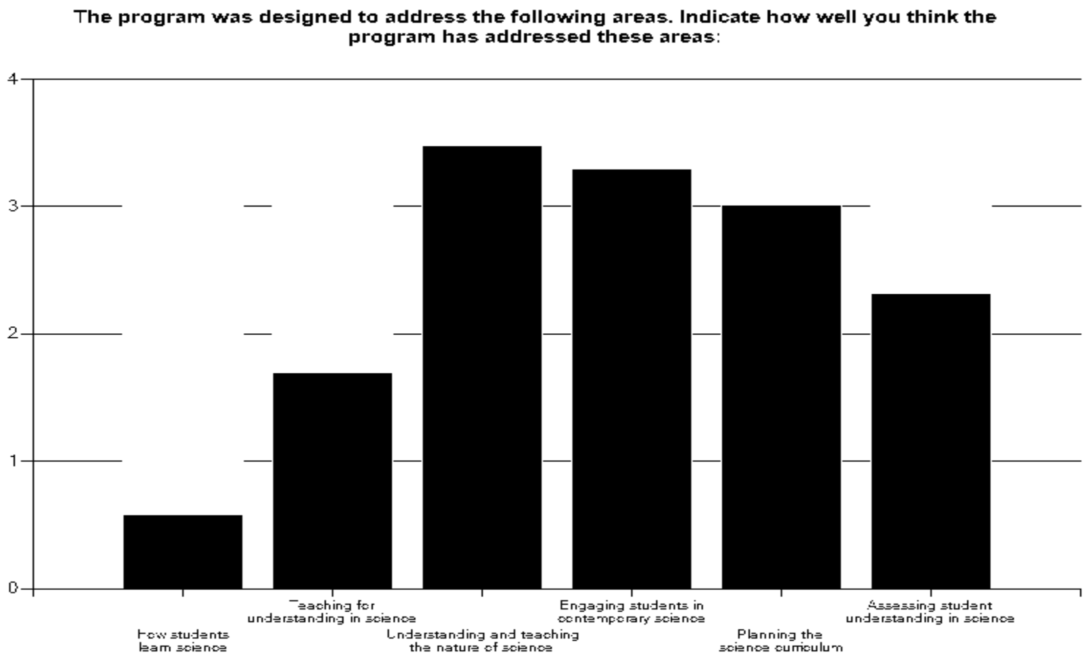

Figure 1: How well did the program identify the six areas.

In addition, participants were asked how confident do they feel in providing some leadership in professional learning in science as a result of this program. The responses are represented below in Figure 2.

Again the maximum rating average possible is 4.0. Most teachers felt quite confident to lead some professional learning in science as a result of this program with another teacher or with a small group of teachers. This response indicates the importance of participants having another member from their school participating in the same program, sharing similar learning experiences if they are to feel more confident to do similar things back in their own school. It is pleasing that there are quite positive responses indicating some confidence to undertake the leadership in such professional learning in science in a variety of ways in their schools. Indeed some participants actually undertook some professional learning in science in their schools as their chosen 'mini' action research project.

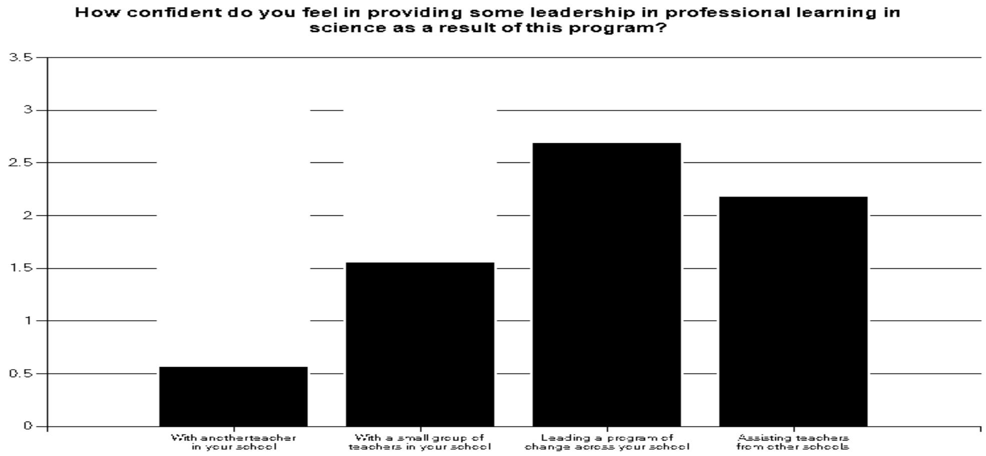

Figure 2: Confidence in providing some leadership in science.

Participants have also indicated increased confidence in their content knowledge after the program. The comparison can be made between the Figure 3 below. This figure indicates that participant confidence had increased in all content areas, with the exception of perhaps the particle theory, although even the average rating for this has also increased from 0.50 to 0.97. Again this figure indicates average ratings where the maximum score is 4.0.

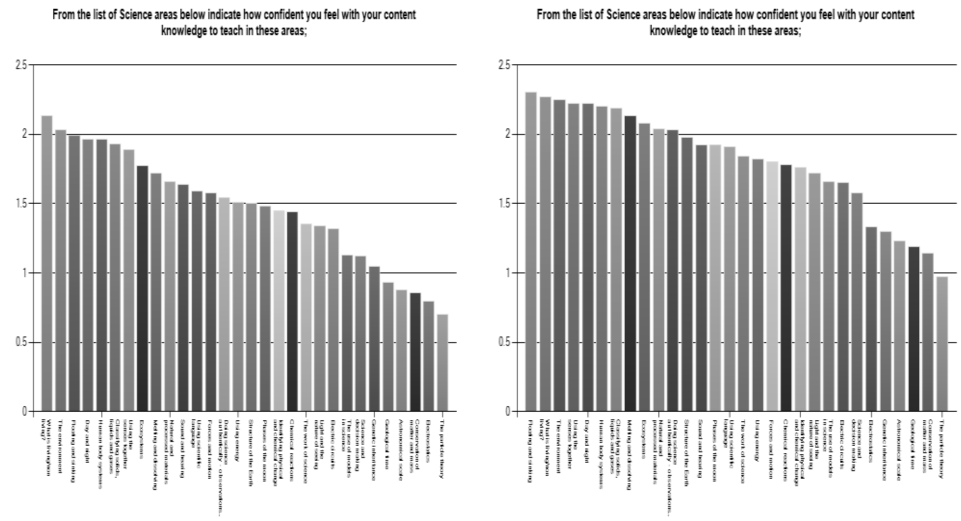

Figure 3: Confidence in their own knowledge of particular science content areas pre-program (on the left) and post program (on the right)

Legend for Figure 3: The order of content areas from left to right are:
Floating and sinking
What is living/ non living
The environment
Using the senses together
Day and night
Human body systems
Classifying solids, liquids and gases
Melting and dissolving
Ecosystems
Natural and processed materials
Doing science authentically – observation
Structure of the Earth
Sound and hearing
Phases of the moon
Using scientific language
The work of science
Using energy
Chemical reactions
Identifying physical and chemical change
Light and the nature of seeing
The use of models in science
Electric circuits
Science and decision-making
Electrostatics
Genetic inheritance
Astronomical scale
Geological time
Conservation of matter and mass
The particle theory

The maximum score possible in this confidence scale is 4.0 where this represents very confident. Other alternatives in this scale included quite confident, a little bit confident and not confident at all.

The increase in confidence in this range of content knowledge is important from a number of perspectives. Not only does it generally indicate increased confidence as a result of the program, but the range of topics is content knowledge that spans the P-10 (ages 5-15) range and not just content primary teachers would be expected to encounter in the P-6 range, the years of primary school education in Victoria. The more abstract ideas of Astronomical Scale, Geological time, Conservation of Matter and Mass and The Particle

Model, while still presenting some challenges for teachers in terms of their confidence to each in these areas, have shown some increase to the category “a little but confident”.

Summary of reflections from the program.

Throughout the program there were a number of opportunities for participants to reflect on their learning. Many of these tasks were structured in a variety of ways in order to expand participants’ knowledge of possible reflective strategies. What is presented here however, is a summary of those reflection with particular reference to the participants’ understanding of science. All reflections are from different participants in the program.

> Investigating values linked to science. I was interested in determining if the personal statements [about science] were true of false. There were some statements that challenged me to think about my understandings of science in schools and our approach to the delivery of the science curriculum.
>
> Many science topics may not be as scary to teach as I thought. Many science ideas can be taught from one topic.
>
> Teachers and students can ask and solve questions together, without actually knowing all the answers.
>
> Science is everywhere. A great question is “What science is in that?”
>
> This PD has given me a different perspective about the way science is taught in school and has made me reflect on the way I teach science to my students. (I currently teach what I know or what I am comfortable with… when I challenge my students to do the opposite).
>
> Up until now I viewed my role as a science teacher as the medium through which students learn lots of ‘facts’ – or ‘get to know things’. Now I’ve changed this view…[and] think it is my role to encourage students to be open to the idea that thoughts and ideas change and that we need to be open to this, basing it on justifications.
>
> If we say we value challenging student ideas about science then what are the issues that arise for teaching science?... With more confidence in my own ability I am now willing to let go of the reins and give them to the students more.

Not all comments were positive.

> [I was] scared about the student reactions to the inquiry approach when they expect teacher led lessons or send out negative vibes.
>
> I feel less confident in leading Science than before this session.

And some time after the professional learning program concluded, one of the comments was:

> I just wanted to report back…we did our first science session this morning. The experiment was a complete disaster…apart from this the lesson went really, really well. I’m in love with KWL…because we discussed the answers and there were heaps of great questions and it was generally a really engaged and high-quality discussion. Personally I’m spending a bit of time getting myself organised and setting some goals (motivated by the PD). I’m feeling much better about my teaching and also much more enthusiastic about things. Thank you , science PD! You’ve put me back on track!

Responses to open-ended questions

Much of the Day 3 program was structured around sharing and reflecting on the activities participants had undertaken in the two to four weeks that had elapsed since Day 2. Where possible this was done in pairs from the same school, in part to further encourage the development of ‘school buddies’ for mutual and subsequent support for further professional growth.

The first half of Day 3 was substantially devoted to participants, in pairs, preparing presentations about what they had tried by way of different approaches to teaching science since Day 2, and then making these presentations to the whole cohort. Six questions were given to participants to scaffold the presentations ('what was done? or learnt?'; 'why this?'; 'feelings, worries, uncertainties before doing this?'; 'what was the effect on you? your students?'; 'what implications has this for your teaching?'; 'what do you plan for the future?').

Before the presentations began, each member of the cohort was given one of these six focus questions and asked to identify common themes across presentations relevant to the question. Each individual made notes of the themes they identified. All those with the same focus question then prepared a short summary of their notes to feed back to the whole cohort. The individual notes were collected and form part of the evaluation data reported in this paper.

Some examples of themes identified, across all cohorts:

1. What was done or learnt from this experience?
   - A wide range of teaching strategies were used in the program and were specifically mentioned as ways to probe students' prior views on a topic.
   - There is an increased awareness of resources (*Science Continuum P-10* and *Primary Connections*), and how to use them.
   - Participants reported an increased confidence in and flexibility when teaching science. They commented that they (the teachers) must engage the children and ensure that they are involved in the teaching and learning.
2. Why this?
   - The reflective tools were easy to take back and incorporate immediately into class…These tools made the teacher and their students think more carefully about what they were doing and why.
   - The resources demonstrated helped to draw links between science and other curriculum areas e.g. literacy.
   - Teachers we interested to involve other teachers at their school and make science more meaningful
6. What do you plan for the future?
   - Participants would plan units of work using the resources presented e.g. *Primary Connections*.
   - Participants identified the need to incorporate the tools for reflection into their teaching more often.
   - Participants felt that you could teach science without having to be an expert.
   - Participants wanted to give greater recognition of student prior knowledge and awareness of science in the students' world**.**

Links between these consequences and development/ implementation approaches

So far, one issue stands out as overwhelmingly important for the generally very positive consequences of the program. That is the very clear and strong concern with engaging the participating teachers in active and meaningful learning during the program – a clear concern with how the program was taught, as well as what issues were addressed. Of specific importance has been the way the program has made legitimate uses of the pedagogical approaches argued during the program to be important for student learning, and thus a clear demonstration that those things argued by the program presenters to be of significance for learning were indeed valued sufficiently that these were used by those presenters.

In terms of future plans for this professional learning program, there is a commitment from DEECD to continue this program in 2010, however with a new set of participants, rather than focusing on the further development of those who have already participated. This strategy is focused on building the capacity of primary teachers in teaching science across the state, rather than developing the capacity of a limited number of primary teachers.

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SCIENCE FOR SUSTAINABILITY: CONTEXTUALISING PROBLEM BASED LEARNING

Roger Cutting

University of Plymouth
rcutting@plymouth.ac.uk

Orla Kelly

University of Plymouth
okelly@plymouth.ac.uk

ABSTRACT

In the last decade a number of low environmental impact communities have been established across the UK. These communities are characterised by self-built dwellings, self-reliance and an attempt to live at 'one world' levels of consumption.
In the last two years a module delivered to science education students at the University of Plymouth (UK) have been based on problem-based learning. These have been laboratory based and have utilised role-play and/or short narrative scenarios. The problems have therefore been 'provided' and have been fictitious.

Following evaluation, it was decided to include real problems and low impact communities were identified as a perfect place to find such problems. In early 2010 students visited and worked with local low impact communities, identifying problems that such sustainable living provides and began to research and eventually suggest potential outcomes. The science-based problems that formed the basis of this part of the module are therefore appropriately contextualised and the outcomes (including negatives) have direct application.
The students unanimously reported that they felt that they learned more about the issues relating to sustainability and science and that the context of real tasks was a qualitative improvement in the problem-based approach. However, they remained unconfident about using sustainability-based science in their own teaching.

Keywords: *Sustainability science, Problem based learning, Low impact communities, Science teaching.*

1. INTRODUCTION

While the issue of Global Warming has taken centre stage recently with the UN Climate Change Conference in Copenhagen (2009) the degradation of the environment seemingly continues. Every indicator of global environmental health seems, at present to be moving towards a more critical position (Steffen, W. et al (2004) p336). Finding our way forward and formulating strategies to ameliorate these impacts will undoubtedly be the great challenge and enterprise of the 21st century and one that will require a generation equipped with the appropriate skills, intellectual resources and creative invention to embark upon this endeavour. As educators and teachers of this future generation we seem to have accepted the responsibility for such an empowerment and we have not been slow to respond. In the last three decades there has undoubtedly been a robust response in the promotion of environmental education and education for sustainability both of which have begun to influence curricula in many countries and at many academic levels (Scott, 2009). Indeed, we now find ourselves at the mid way point in the UN Decade for Education for Sustainability.

In the field of science we have seen the advent and development of 'Sustainability Science' as not only a field of research, but even as a new research paradigm (Clark and Dickson, 2003). We have seen issues surrounding sustainability and the environment begin to be included in teaching programmes and their has been a distinct shift away from education merely about environment towards an education for the environment, one that promotes its conservation. (Reid and Scott, 2006)

However, whether these developments have had sufficient impact on curricula is questionable. In the United Kingdom (UK) significant progress has been made at elementary levels (Peacock, 2004) but a brief examination of the Science syllabuses for 16+ examinations in the UK shows little that directly relates to education for sustainability (EfS). The 18+ syllabuses (GCE Advanced Level - the primary matriculation qualification to UK universities) for Physics and Chemistry have no content that relates to EfS. Students may arrive at undergraduate level study with only a rudimentary understanding of sustainability issues generally and little comprehension of the contribution of science to the sustainability agenda.

Combine this with the growing criticism levelled at traditional 'expository' approaches to science teaching (Carillo, Lee and Rickey (2005), Johnstone and Al-Shuaili (2001), Hofstein and Lunetta (2004), McDonnell, O'Conner and Seery (2007)) and we fall someway short of the dynamic, engaging, cross-curricula approaches that are seen as necessary to deliver a sustainability science (Komiyama and Takeuchi, 2006).

New methods and approaches of science teaching need to be developed if we, as a generation of educationists are to prepare our students to meet the environmental challenges of the future. We need methods that promote creative and innovative thinking, encourage criticality and that recognise, through contextualisation, the limitations of science methodologies. In short, methods of science teaching that simply promote good science practice.

Problem Based Learning and the Science of Sustainability

In the last decade, PBL has become "one of the most popular curricula innovations in higher education" (Tan, 2004:p170). It requires a shift in focus from the traditional, didactic method of teaching, where the lecturer is the expert, transmitting knowledge to the students with coverage of content the focus, to a student-centred style where students are problem solvers, the lecturer is in a coaching or facilitating role, and the problem is the focus of the learning from which content is derived. (Tan, 2004). The reasons for the effectiveness of such approaches are elusive, but may relate to different learning styles. PBL encourages what Petty (2004) has described as 'deep learning'; a constructivist approach where learning is achieved by adapting and building on prior knowledge, skills and concepts thereby allowing the learner to seek meaning for themselves and not the meaning as constructed by their teacher. More recently, PBL is currently receiving much attention in physics, chemistry and biology education. (Freitas, Jiménez, & Mellado 2004; Ibáñez-Orcajo & Martínez-Aznar 2007; Kelly & Finlayson 2007; Lee 2007) The benefits of this problem-based approach, particularly in science, are summarised well by Tan (2004):

- Bridges the gap between theory and practice
- Enables development of real world competencies – which are strongly linked with the scientific method

- Promotes a constructivist approach to learning, which is extensively practiced in science teaching (Driver 1983).

Collaborative group work is a significant element of the approach. Exley and Dennick (2004) describe how, during group activities, learners can be provoked into thinking deeply by questions from their peers and teachers that challenge students and encourage them to take ownership of their own learning and can support a constructivist approach to learning.

Given the proposed benefits of PBL and the limitations of the expository model of practical work, problem-based approaches to science teaching are proposed as a possible approach to the teaching of sustainability science.

Low Impact Communities, Problem Based Learning and Sustainability Science

In 2007, a module entitled 'Foundations of Science' was offered to first year undergraduate science specialists enrolled on an Initial Teacher Training programme at the University of Plymouth. This particular module had gone through a review process that had led to it being redesigned to be delivered entirely through a PBL approach. The module was monitored across the year and the student's experiences were reviewed at strategic points (Kelly and Cutting, 2008). Generally, the module proved successful, but it was felt that the problems that the students are asked to address became known to the staff team and in the following year lost something of their originality. As a result, it was decided to review part of the module (in the first instance) and secondly, to address problems relating to the science of sustainable living.

In the last decade a number of low environmental impact communities have been established within the British countryside (Cook, 2008). They are singular examples of people in the industrialised world attempting to live very near 'One World' standard of resource use (WWF, 2006; Knight, 2007). This means that they have the level of resource demand that could be sustained by the entire planetary population, and that they are consequently the nearest examples we have in the U.K. of "sustainable living". They involve groups of people who are living in self-built dwellings unconnected to mains water, drainage, sewerage, gas or electricity. They combine a strong ethos of self-reliance, which ensures that their needs are largely provided from a small and predominantly local resource base thereby causing minimal disruption to the environment. Recent work describes low impact communities (LIC's) and variously considers their social, environmental and economic merits (Pickerill & Maxey, 2009; Laughton, 2008; Rosen, 2008) and this study is based on the work of LIC's that have been established in the south west of England.

LIC's present intriguing opportunities within the context of sustainable living for problem based learning especially in relation to the application of practical everyday science. These increasingly popular 'sustainable community' initiatives are populated by young people who often, at their own admission, have no specific skills relating to sustainable living and are therefore themselves on a very steep learning curve. The problems they face include building energy efficiency into structures and shelters, sustainable food production and storage, soil husbandry, power production (in terms of heat and electricity) as well as water supply and waste treatment and discharge. All of these problems are significant in relation to minimising the environmental impact of these communities and have still yet to be resolved in some sites. Providing solutions and making improvements will necessarily involve the practical application of science. The potential for the use of these challenges as means of contextualising PBL in science was recognised by the staff team and hence formed the basis for the second part of the Foundations of Science module. and provided research-based problems for the Year 1 Foundations of Science module.

More than merely land occupations, these LIC's represent a realistic attempt to live sustainably yet in the 21st century. However, they also provide significant scope to extend the student experience of sustainability beyond the theoretical confines and allow them to experience first hand the practical problems and issues of low impact living.

The Project

This took place with a group of 17 students in early 2010. It involved students who were on a four-year, undergraduate initial teacher training programme, with a specialism in science education and training to teach primary school age children. The project occupied 12 hours (excluding group preparation) within a 50 hour taught module. The first part of the module had already introduced the students to PBL through a series of varied science based problems (Kelly and Cutting, 2008).

The first part of the revised element involved two visits to so called Low Impact Communities in the South West peninsula of southern England. Before these visits the students were asked to concentrate on the science aspects of sustainable living and an essential aspect of the methodology was to encourage students to explore their own ideas about the topic and the associated pedagogy in collaboration with their peers, and with the tutor acting as facilitator. Through this process it was intended that they should refine their ideas on science and sustainable living and begin to reflect and evaluate their own potential pedagogical strategies as future science specialists.

The students visited the Steward Wood, Woodland Community, near Moretonhampstead, Devon, UK. (Steward community woodland 2010) This is a community of 18 adults and 5 children. During the visit the students looked particularly at the science aspects of such living with particular emphasis on power, food production and soil husbandry as well as the nature of the construction of dwellings and the treatment of waste products.

The following week the students visited the Forest Garden Project and the Permaculture gardens at Schumacher College, Dartington, Totnes, UK. (Schumacher College 2010) Here they were encouraged to focus on the application of ecological principles relating to these alternative agricultural approaches to food production.

Following the visits and a debrief/review the PBL element of the course was reintroduced.

The students were then divided into groups and asked to investigate the application of their experiences acquired during the visits. The cohort was asked to research and present their findings on different aspects relating to identified practical science problems related to low impact living. A limit of £3000 was set to any suggested schemes. Their research findings were then presented through the production of academic posters and by short presentations.

Finally, the students were asked to critically evaluate their own learning and the potential that LIC's and sustainability science provided for a future basis for their own science teaching.

Research Questions

A number of research questions were identified prior to the delivery of this unit and they included:

1. How do the students perceive the world of the future and what is the present day contribution of science teaching?
2. What, if any, is the impact on student's views of sustainability having visited the communities?
3. What, if any, is the impact on students views of the nature and application of science related to the sustainability having visited communities?
4. What is the educational value of such sites in the promotion of Education for Sustainability?
5. Does the use of genuine issues relating to sustainable living better contextualise a problem based learning approach?

3. METHODOLOGY

The following methods were carried out. The numbers correspond to the research questions.

Research Question 1

Discussion (both class based and on-line) took place in small groups on a number of questions, including;

Will science save the world?
What will the world look like in 30 years?
How will Global Warming affect you?
Will you enjoy better, worse, similar living standards compared to those of your parents?
How will the growing global population be fed?
Should the science of sustainability be a compulsory part of the science curriculum?

Each group reported their views and a wider debate took place and was audio-recorded.

Research Question 2

Prior to the first visit to an LIC the students were asked to draw a picture, or a diagrammatical representation, of the major components of a sustainable community. A content analysis was then carried out on these. The students also completed a two-part questionnaire, which explored their own ideas about sustainability. Part one was filled out prior to the first visit to a LIC and dealt with their expectations. Part two was completed after the visit and concerned how their expectations had matched their experiences.

Research Question 3, 4 & 5

A focus group debate about low impact living and science was carried out after the visits. The discussion was audio-recorded and analysed using Nvivo 8 software. Students were also asked to keep a reflective diary.

4. RESULTS

Research Question 1

In relation to the first research question the student responses given during the discussion are summarized as follows;

1. All students in the cohort expressed the view that 'technology' would provide the answers to global problems.

2. Many felt optimistic about the future and held the view that the world in 30 years time would be similar to today – but based on 'substitute' resources (e.g. Hydrogen for oil, nuclear for fossil fuels).
3. Most saw Global Warming as an issue affecting the Developing World and not of great concern to Developed World.
4. All students in the cohort thought that they would enjoy the same or better living standards than their parent's generation.
5. All saw future technologies as the way in which the world's population could be fed.
6. While many saw sustainability as important, most did not see it as an essential component of the school science curriculum.

Research Question 2

The picture/diagrammatic representations provided an intriguing insight into their initial ideas of low impact communities.

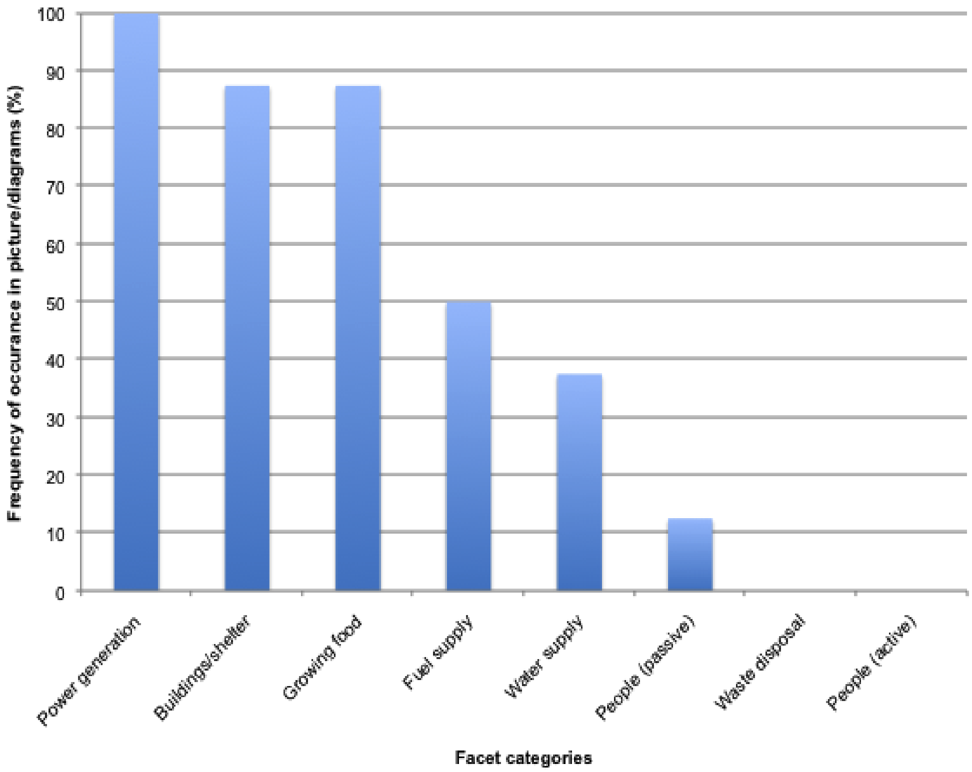

Figure 1. The primary facets included in student's pictorial or diagrammatical representations of the major components of sustainable living.

Figure 1 shows the percentage frequency of identified facets appearing in the pictorial and diagrammatic representations. The picture analysis showed that the most commonly drawn components of LIC's were those aspects that were involved in production. Electrical production (be it through wind generators or solar panels) featured in some way in all of the pictures produced, as did food production and dwellings. Intriguingly no students drew or made representation of toilets, waste treatment and energy efficiency or food storage. Furthermore, no representation of the people in the communities was made (beyond the decorative). The major components concerned the ways in which power, food and shelter could be provided simply in alternative ways.

The pre-visit questionnaire recorded that most students expressed some degree of trepidation at the prospect of the visit although it was also seen as potentially intriguing and interesting. There was a common sense that these community members would be living a very basic, almost pre-industrial life-style with high levels of self-sufficiency, based on low-level technologies.

The post visit answers contrasted both with the expectations of the cohort prior to these visits and to the pictures that had initially been produced. Nearly all students reported a better understanding of the relationship between low impact living and sustainability. They had generally expected the communities to be self-sufficient and generally eschewing modern technology. The cohort reported a much better understanding of the issues related to sustainable food production, not only related to soil husbandry and organic produce, but also the primary limitation of storage (a point few had ever considered).

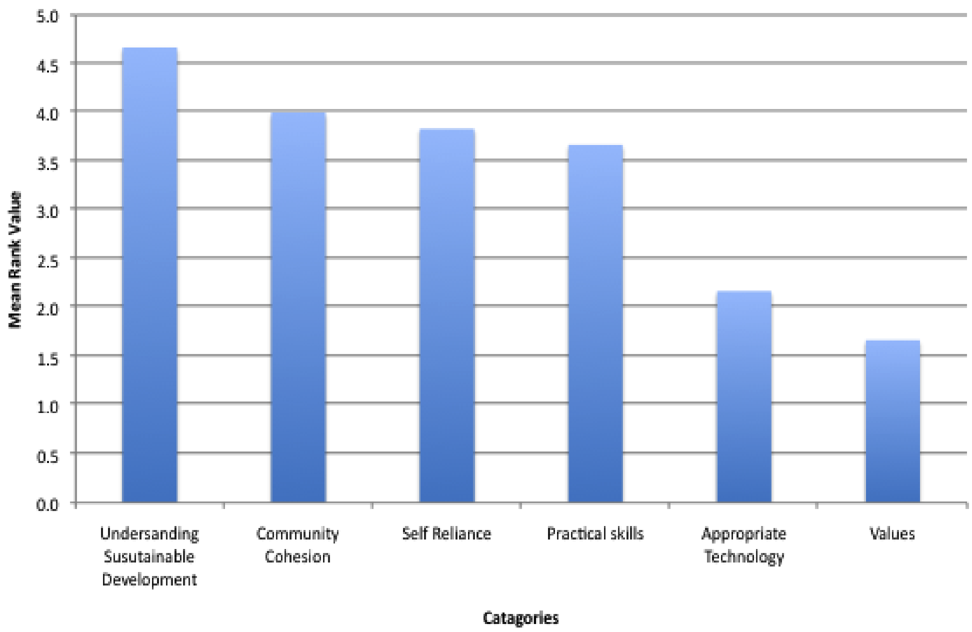

Figure 2. The mean rank scores for post-visit feedback questionnaire asking students to rank what they saw as the most important aspects of sustainable living.

Figure 2 shows the rank scores for what the students saw as the most important aspects of LIC's after the visit. These were 'Understanding Sustainable Development' and 'Community Cohesion'. During the post visit focus group discussion the students expressed the views that 'community was more important than sustainability' and that they had come to appreciate the importance of human relationships in community living.

When asked the question "What is the greatest obstacle to you joining such a community?" the answer, nearly universally was issues relating to sanitation and hygiene. Interestingly, toilets and waste treatment had not been considered prior to the visits.

Research Question 3

During the focus group discussion it became apparent that the students had never thought of sustainability science as a mechanism for the delivery of elementary science components of the National Curriculum. Indeed, most of the students had never covered any topic relating to sustainability or sustainable living in their pre-university science courses. There was a general agreement that they had drawn wind generators and solar panels on their pictorial representations of sustainable communities, but they did not know how much power a wind generator could produce and none knew how a photovoltaic cell produced electricity.

There was some concern that environmental science may be too complicated, or too political a subject to form the basis for general science teaching and some felt that while science could play a role in the promotion of sustainability that there was a certain amount of 'environmental wearyness' related to environmental issues. All students in the cohort however thought teaching science through environmental and/or sustainability issues was worthwhile and that teachers should at least try to apply science more to such issues.

Research Question 4

The students unanimously agreed that they had learnt from the visits, the discussion session and the problem based approach. However, the students reported that while they had learnt about a number of issues relating to sustainable living, that both their personal behaviours had not changed and that their approach to teaching science would also probably remain unchanged. Most agreed that they would take children to the sites, but generally felt that such sites were limited in terms of primary level science education, preferring more conventional and mainstream sustainability events and/or exhibitions. They did however, see LIC's as interesting social experiments and while they were very aware of some of the contradictions of this lifestyle, they thought them worthwhile.

Research Question 5

In relation to the PBL science assignment that concluded the unit, the students unanimously agreed that a 'real' problem or task (as opposed to a fictitious issue) provided the task with context and depth. Students reported taking the problem very seriously in terms of researching the science behind the suggested building improvements and that not only were their decisions confined by a budget, but that improvements and resulting savings were minimal compared to the expenditure. The problem not only promoted group learning but also provided a context for decision-making processes and real limits to what the application of sustainability science could provide. One intriguing comment from the focus group was that they found information about alternative power and heating schemes was fairly freely available and the technology was well advanced and obtainable within the budget. However, the technologies related to waste treatment are far more elusive, expensive and on occasion inappropriate. Several students related this to their drawn pictorial representations of sustainable communities, in that images of sustainability often include technologies to produce power (or reduce its use) that may be inappropriate in terms of output and costs.

All students in the cohort affirmed that they had learnt from the problem and had come to appreciate that the science of low impact living is often overlooked in favour of large, top down 'high tech' science approaches.

5. CONCLUSIONS

Education for Sustainability has a vital role in educating for the future. However, in Science teaching we perhaps encourage students to look to science to solve planetary scale problems. Usually, the magnitude of such problems and the complexity of the scientific response can seem abstracted and beyond the experience (and understanding) of many. Applying science at the level of a sustainable community may have the potential to promote low level practical science as a means of providing sustainable solutions to sustainability problems and provide a context and role for science to be very much part of practical local solutions, rather than a perceived cause of global problems.

The students involved in this module initially looked for large-scale solutions, replacing one fuel with another and suggesting the new technologies of genetics and gene manipulation as a means of increasing food production. They approached global problems from the viewpoint of maintaining (and increasing) production 'simply' through alternative means.

By working on low level technology projects (such as environmentally benign sewage treatment, investigating carbon neutral methods of food storage, evaluating the effectiveness of small scale production of electricity from hydro or wind) the students apply their science knowledge, but in a context of costs, complexity, site suitability, maintenance etc.

PBL has been shown to be an effective tool in increasing student's confidence in scientific methods and in promoting understanding of science concepts and principles.(Kelly and Cutting 2008) However, when applied to real problems it becomes not only a teaching methodology that promotes understanding, but one that also encourages engagement with people. The students not only model the experience of science research, but also are actively involved in its application.

The student's attitudes to the science of sustainability were undoubtedly affected by this use of PBL, but although they could see the relevance of the material they were not enthusiastic about using it as an approach in their own future teaching. This is a generation of future teachers that have themselves been educated throughout the UN Decade of Education for Sustainability, a generation that have grown up with environmental education. They appreciated the importance of sustainability and agreed that it should be part of a curriculum, even part of a science curriculum, however, there was a sense that sustainability issues would be best addressed elsewhere and their understanding of the science of sustainability was generally poor. Therefore, as educators we need to challenge policy makers and influence curriculum guidance to ensure sustainability is included across all ages and ranges within the compulsory education sector. The need for a discussion and debate about the role and place of education for sustainability in our compulsory curricula is suggested as an implication from this research.

However, the application of science to real problems related to sustainability at least allowed them to see the problems and solutions in a context that is generally one of constraints. On some occasions those constraints will be physical (insufficient discharge from a stream, not deep enough soil for a heat pump) at others economic, but the importance of such problems is that it places science at the heart of a community of people. Decisions, solutions and compromises to the localised problems of sustainability are made at a community level.

A problem for science teaching is that science is often seen as the cause of global scale problems, and a problem for science teachers is that they seldom have the experience, knowledge and familiarity of the science of sustainability to effectively address these issues, beyond suggesting alternative technologies that they know little about. Lack of robust knowledge, and a failure to appreciate the context, constraints and impacts of suggested solutions will merely result in the failure of science to provide any solutions. The science of sustainability, like any other branch of science requires students (and especially student teachers) to be both confident in their scientific approach and rigorously critical of their outcomes. However, through community-based problems, students can see the limitations to technological solutions as well as experiencing a decision-making process. At the community level science relates more openly to people, its application becomes democratic and ethical. It can become less technocentric and more outward looking.

Using PBL in relation to the science of sustainable living does not promote a new science. It does however promote good science, a science of both rigour and application. It is through such approaches that we can hope to provide teachers and students of the future with the confidence and assuredness that will be required to face the environmental crisis. Our legacy must not be the problems, but the rather the provision of skills and approaches that provide solutions.

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Physics and nature – A new COURSE for THE first year students OF Physics EDUCATION

Mojca Čepič

University of Ljubljana,

Faculty of Education

mojca.cepic@pef.uni-lj.si

Katarina Susman

University of Ljubljana,

Faculty of Education

katarina.susman@pef.uni-lj.si

Saša Ziherl

University of Ljubljana,

Faculty of Education

sasa.ziherl@pef.uni-lj.si

Jerneja Pavlin

University of Ljubljana,

Faculty of Education

jerneja.pavlin@pef.uni-lj.si

Jure Bajc

University of Ljubljana,

Faculty of Education

jure.bajc@pef.uni-lj.si

Nataša Vaupotič

University of Maribor,

Faculty of Natural Sciences and Mathematics

natasa.vaupotic@uni-mb.si

ABSTRACT

A new course called Physics and nature was introduced for the first year students of physics education. Ten different topics, relevant in the present research problems and motivated by the everyday life experiences were adapted to the teaching units at the conceptual level requiring very limited pre-knowledge of physics. The topics were studied through a combination of lectures, laboratory work and seminars.

In this contribution we give the aims of the course, we briefly present the topics (teaching units) and show few excerpts from its realization. We present the analysis of the student assessment carried out before and after the course.

Keywords: *nature, physics, physics education, motivation, in-service training, context based approach.*

INTRODUCTION

The recent implementation of the Bologna programs into the university studies in Slovenia allowed for introduction of new courses and topics. The usual trend was shortening of the courses and depletion of the previously thought topics. But in some rare cases courses that are obligatory although having only the informative message were possible to be introduced. In this contribution we present an example of such an experience: the introduction of a new course Physics and Nature, its structure, the topics taught, and the evaluation of the impact on the knowledge obtained by the students.

The Faculty of Education at University of Ljubljana offers double major university study programs for future teachers in the obligatory lower secondary school, which is similar as the junior high school in some countries. Students elect the combination of two study fields. Due to the organizational reasons the possibilities are limited and defined in advance (Table 1, above diagonal). Within the double major teacher's study program students can study a combination of the two out of the following fields: biology, chemistry, computer science, home economics, mathematics, physics or technology. The program was constructed to allow for all combinations (except the combination of biology with mathematics or computer sciences, which is not allowed by the explicit request of the biologists), as seen in Table 1 below the diagonal.

The Slovenian needs for the double major teachers are approximately 30-40 graduates per year for combinations with mathematics, while approximately 15-20 graduates per year are needed in the combinations of other fields. These low numbers pose additional organizational problems, as students at different combinations have to merge during the lectures of the same course. For example, all students of physics in combinations with chemistry, computer science, mathematics and technology attend a single lecture of physics and the schedule has to be organized in such a way that the four groups have the same cross section of available time for these lectures. Therefore it was decided that the double major program is organized only for the most popular combinations of two study fields, as seen in Table 1, above the diagonal.

Table 1. Possible enrolment combinations for the double major studies. The combinations that are possible to enroll are presented above the diagonal. The combinations that are allowed by the program are marked below the diagonal.

	Biology	Chemistry	Computer science	Home economics	Mathematics	Physics	Technology
Biology		X		X			
Chemistry	X			X		X	X
Computer science		X			X	X	X
Home economics	X	X	X				
Mathematics		X	X	X		X	X
Physics	X	X	X	X	X		X
Technology	X	X	X	X	X	X	

To allow for the variety of combinations, the program possesses a set of basic scientific courses: mathematics, physics and chemistry, the courses specific for the two chosen study fields and the general courses in the theory of education. However, if one of the study fields is mathematics, physics or chemistry, students obtain the required general scientific or mathematical knowledge within the courses specific to the study field in the combination. Due to the rigid requirements of Bologna framework, all students have to collect the same number of credit points (ECTS). For such students one (or two) of the basic scientific courses thus have to be replaced by another course, specifically designed for such “favorable” combinations.

In this contribution we present one of these courses, a course Physics and nature, which is obligatory for combinations of physics with chemistry, computer science, mathematics and technology. The course discusses interdisciplinary problems, contemporary research problems, and other topics, which are motivated by the everyday experiences. Due to the ECTS requirements, the course is placed in the first semester of the study, where practically no verifiable knowledge of physics is present yet. One has to bear in mind that students are coming from various high schools, some of them having no prior physics course at all. Therefore the course and its topics have to be prepared and presented in a way, which does not require the pre-knowledge in physics and the explanations had to be build on experiments, observations and the semi quantitative reasoning only. The type of lecturing should follow the advices for lectures popularizing the natural sciences.

The paper is organized as follows: the course organization and the topics are presented in the next section. The purpose of the descriptive case study of a teaching innovation was to obtain information on two different aspects of the course: the acquired knowledge and how interesting the topics and the course as a whole were for the students. Methods to acquire the information are given in the section Methods which is followed by the section reporting on the Results. In Conclusions we discuss the possibility of introducing such topics into the high school in order to maintain or even stimulate the motivation for physics and natural sciences in general, which is in decline almost everywhere in Europe.

COURSE ORGANIZATION AND TOPICS

As described before, the initial motivation for the course was bizarre. We had to construct a physics course which would not add a serious study load to students but would provide the missing 5 ECTS required by the rigid rules of Bologna in some “favorable” double major combinations of studies. The course had to be placed in the first semester of the study, where the students’ knowledge of physics is unpredictable, as students come from various high schools, some not having physics at all.

The course in duration of one semester (15 weeks) consists of one hour and a half of lectures followed by one hour and a half of laboratory per week. In addition, during the seminar at the end of the course, each student has to present results of a small practical research problem. As our studies notoriously suffer from low enrolment and a number of students with relatively low motivation, the intention was to introduce interdisciplinary and modern topics to increase the motivation for further studies. The topics were chosen such to allow for the laboratory work with motivating and interesting experiments. The choice was the following:

1. *Earthquakes and waves*

The unpredictability of earthquakes and the reasons for their occurrence is discussed during the lecture. Longitudinal and transversal waves are introduced and connected to the real situations during the earthquakes. The secondary effects of earthquakes such as tsunami are presented as well. In the laboratory work students study the stability of model houses of different heights and they make a prototype seismometer.

2. *Dia-, para- and ferromagnetism*

The lecture discusses three different types of magnetism and shows that ferromagnetic materials are not the only materials interacting with magnetic field. It is shown that interactions of paramagnetic materials with the magnetic field are similar to the ferromagnetic ones, only weaker. However diamagnetic materials are repelled by the nonhomogeneous magnetic field. Students study weak magnetic interactions. They observe how the aluminum coin is attracted and how the watery grape is repelled by a strong magnet. They also study the behavior of the superconducting pellet in the vicinity of a strong magnet and the Meissner effect (Čepič, 2007).

3. *Density and buoyancy with respect to the life in water*

The lecture consists of a short résumé of density and the buoyancy; the mechanisms of water animals which provide them stability at a given depth as well as the ability to control and change the depth are discussed. In the laboratory work they construct the Cartesian diver with a special emphasis on keeping the diver at a certain depth in the water.

Students experience personally that pressure affects the average density and the corresponding buoyancy of the diver, however they also experience that the general equilibrium is unstable and has to be controlled constantly. This experiment serves as an illustration that fish have to apply control to remain at a given depth, swimming as a short term control and the constant volume of the fish bladder as a longer term control mechanism.

4. *Temperature control in living species*

The lecture presents the energy balance of the living species with constant temperature. The analysis of the balance with respect to the surface to volume ration was analyzed and illustrated by the experiment where pieces of cheese having different sizes were put in the microwave oven. Students experienced a cognitive conflict as larger pieces melted first and the smallest remain hard. The experiment serves as an illustration that when the heat is released in the whole volume of the body, larger animals have smaller surface to volume ratio which makes it easier to maintain the body temperature higher than the surrounding temperature (Planinšič *et al.*, 2009).

5. *Diffusion and osmosis as transport mechanisms in living species*

The lecture presents the microscopic model of diffusion between regions having different concentrations. For the semi-permeable membranes the phenomenon of osmosis is discussed as well. The importance of these properties in living species is also shown. In the laboratory work students study a toy model of diffusion (Fig.1), where beans of two different colors initially separated in two compartments mix when shaken. Mixing is enabled through an aperture in the fence between the compartments. Students perform the experiment on the small scale individually, with ten beans of each color only. Then they add the results of their simulation together to obtain larger sets of beans showing that the characteristic time for mixing remains the same but the fluctuations are smaller and the possible “demixing” becomes a very unlikely event.

Figure 1: The model for diffusion.

6. *Surface tension and related phenomena*

During the lecture some conceptual problems with respect to the missing interactions at the surface are discussed first. Then the concept of the free energy is introduced in order to bring about better understanding of interactions with various surfaces and the shape of the free surfaces. In the laboratory work students study the dynamics of the flow due to the surface tension pull. They have to make the capillaries by themselves which proves a demanding but a rewarding task (Fig. 2). They also study the shortest street network problem (how to connect four houses with streets having the shortest length altogether) and solve the problem by using a toy model where the streets are soap films.

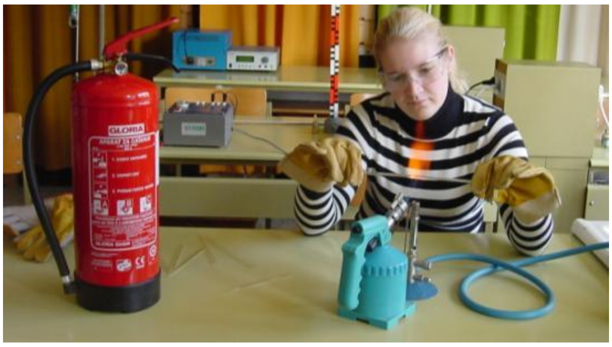


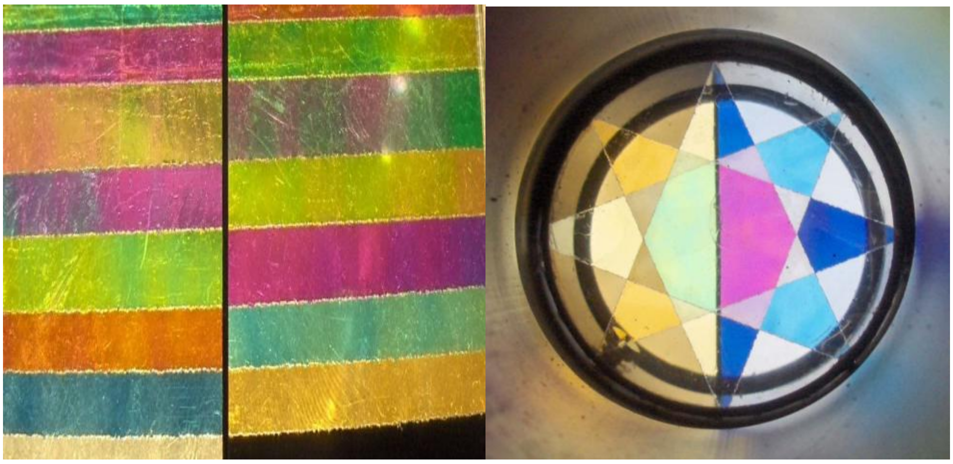
Figure 2 It is difficult to make a capillary.

7. *Phase transitions and transport of water in high trees*

The second and the first order transitions, the undercooling and the superheating phenomena are studied. The dependence of the boiling temperature of water on the pressure is also shown. In the laboratory work students prepare the undercooled water and observe its sudden freezing. They play with liquid nitrogen. This is a source of high enthusiasm. They also pull a transparent plastic tube filled with water to high elevations. The tube is sealed at one side and the other open side is submerged into a beaker filled by water. It is shown that water cannot be pulled up higher than a little less than 10 m, where it starts to boil (Susman *et al.,* 2007). So how can the trees pull water up higher than 10 m?

8. *Polarizers, anisotropic materials and the polarization of light*

The lecture starts by introducing the concept of an anisotropic material such as wood. Then the polarized light and how polarizers can polarize light is discussed. In the laboratory work students become familiar with polarizers, they study the effect of the anisotropic material placed between crossed polarizers on the color of the transmitted light (Babič *et al.,* 2009) and they produce a picture which could be observed through the crossed polarizers only (Fig.3).



(a) (b)

Figure 3 (a) Layers of tape seen through the parallel (left) and crossed (right) polarizers. (b) Three tapes glued one on another in three different directions observed through paralel (left) and crossed (right) polarizers.

9. *Liquid crystals*

Liquid crystals are presented as an example of an optically anisotropic material. It is explained how this property is used in displays. Students made a prototype liquid crystalline cell (Pavlin *et al.,* 2009) and a wedge cell which they use to study the splitting of the light beam due to the anisotropic properties of liquid crystalline prism. They verify the mutual perpendicularity of polarizations in the split beams.

10. *Sports and physics*

The energy and its transformations related to the biomechanics, the reaction times of muscles and the important role of the probability in prediction of the football results was discussed during the lecture. In the laboratory work students tested their reaction times, the reasons for tiredness when walking on the horizontal level and the pre-activation of muscles at jumping (Mathelitsch *et al.*, 2008).

METHODS AND RESULTS

Descriptive case study was done. For each topic students answered the pre-test, which questioned the familiarity of the concepts that were studied during the lectures and laboratory work. The pre-test consisted of two or three very short general questions concerning the next topic in the lecturing sequence.

The course was concluded with a written exam. The exam consisted of 13 questions, some of them demanding more elaborate answers. Each topic was questioned at least once. The general structure was:

- 5 questions were asking for facts, which those students, who attended all the lectures and laboratory work, having made notes regularly, could copy from the notes. Of course, the student's understanding of the topic had to be good enough to know, where to search.

- 6 tasks required description of the experiment, recognition of the experiment photo and/or its description, and explanation of the purpose of the experiment. All the tasks were related to the experiments performed by students themselves.

- 4 tasks required application of the concepts learned during the lectures and laboratory work.

Some of the questions in the written exam were the same as the pre-test questions. The results of these questions are analyzed below in more detail.

The points were distributed to the answers unevenly, because some questions were structured having additional sub-questions. The highest number of possible points was 23.

Because the course was implemented for the first time without any previous experiences of the similar type, our aim was to collect from students as much other information as possible. Therefore we constructed another questionnaire, which aimed to assess how interesting or uninteresting the students found the presented topics, their general impression on the course as well as their suggestions for future implementations. In this paper we discuss in more detail the students' responses related to how interesting they found the presented topics.

RESULTS

The group consisted of the first year students of physics education. Majority of students (13) studied the most popular combination of physics and mathematics. The number of students who studied physics and chemistry (7), physics and computer science (3) and physics and technology (3) was much smaller.

The exam is obligatory for students to proceed to the second year of studies, and almost all of the students attended the exam in the first term. The exam lasted for one hour. As mentioned before, the main "mission" of the course was to motivate the students for the beauty of physics. Therefore the exam did not verify the knowledge acquired by heart or the application of the studied concepts to new problems as is typical for exams in the main courses within the physics study program. Students were allowed to consult the lecture and the laboratory notes.

Although we expected that the achieved marks will be almost exclusively the highest ones, this was not the case. Fig. 4 shows the distribution of marks. Only one student failed, which is extremely low in comparison to the basic courses of physics, where the passing rate is usually less than 50%. As they were told in advance they would be allowed to use the notes, many of them had not considered it necessary to prepare for the exam. However, the attendance of lectures and laboratory work has given them enough knowledge to allow for a passing grade.

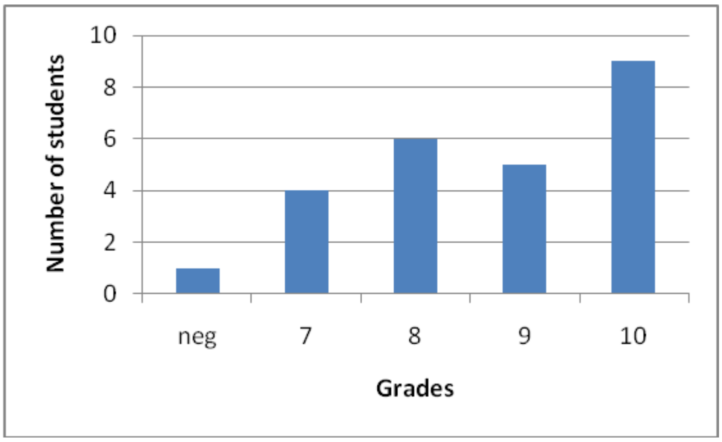


Figure 4 Distribution of the exam grades. Students having 6 or higher passed the exam, 10 is the highest possible grade.

At the beginning of the laboratory work students filled in the pre tests. Each test was composed of three questions related to the theme of the next laboratory work. Some of the questions were designed for checking the level of familiarity with physical concepts and facts. Students were stimulated to write down all the associations or ideas related to the question. From the analysis of the pre tests we were able to detect not only the pre knowledge but we also managed to find out the fields, expressions, terms from physics or from a daily life that were connected to the question. The same questions asked at the post test had, in contrast to the pre tests, the role of appraisement of the terminology and conceptual understanding.

Only the qualitative analysis enabled us to determine the results of the survey. Let us analyze three sample questions with the analysis of students' answers.

Q1: *Compare the terms of magnitude and intensity of the earthquake.*

Q2: How is the kilocalorie (kcal) defined?

Q3: What is osmosis?

24 students took part in the first pre test which included the Q1 on comparison of the magnitude and intensity of the earthquake. Only 5 students gave the correct answer. 4 students did not answer; all the other wrote their ideas of what are the magnitude and/or intensity. The variety of answers is a convincing proof that they have heard about the physical terms such as power, strength, energy, waves, frequency, but they were not able to include them in a logical and conceptually correct statement. At the same time the concepts of magnitude and intensity were sometimes mixed. 23 students who gave an answer used a great number (15) of different terms with ambition to illustrate the magnitude and intensity of the earthquake.

The post test showed a completely different picture. 23 out of 26 students wrote the correct answer using adequate and consistent terminology. Two students had partially correct answers but the way of expressing the idea was correct. There were no incorrect answers and only one student did not answer. One of the possible explanations for the successfulness in answering could be the relevance of the theme with respect to the recent earthquakes. The destructive earthquakes on Haiti close to the time of the exam brought the terminology and terms of the magnitude and intensity to the daily news. Students might become more focused on this topic as they would be if there were no catastrophes at that time. The other possible reason for a large number of correct answers might lie in the fact that students were allowed to consult their notes during the test. Nevertheless this explanation seems less probable since the correctness of other questions was not at the same level.

Tables 2 and 3 show the summary of analysis for Q2 and Q3. The correctness of the answers at the pre and post tests is compared. From the tables one can see the topics that students connected to the question and used to explain the answer.

We also analyzed the responses with respect to the personal opinion of students on different topics, were they interesting for them or not. Although we expected that some of the topics will not be interesting for any of them and some of them would attract most of the students, the results came as a surprise (Figs. 5 and 6). All topics were interesting at least for a few students. Figs. 5 and 6 clearly show the spread of interests and consequently the motivation for students attending the course.

Table 2 The comparison of the pre- and post-test for Q2.

How is the kilocalorie (kcal) defined?							
pre test				post test			
cor.	incorr.	no ans.	explained by/ connected to	corr.	incorr.	no ans.	explained by/ connected to
1	9	14	food (9)	10	15	1	food (7)
			activity, work, burning of material (3)				work, energy, unit of energy (5)
			preserving the personal temperature (2)				other (3)

Table 3 The comparison of the pre- and post-test for Q3.

What is osmosis?							
pre test				post test			
cor.	incorr.	no ans.	explained by/ connected to	cor.	incorr.	no ans.	explained by/ connected to
2	22	3	cells (12)	19	7	0	
			differences in concentrations (10)				

A closer look at Tables 5 and 6 shows that the students interests are different. The same topics which were found the most interesting for many students were found boring for several of them as well. On the other hand, also topics that lecturers considered as more boring cought their attention.

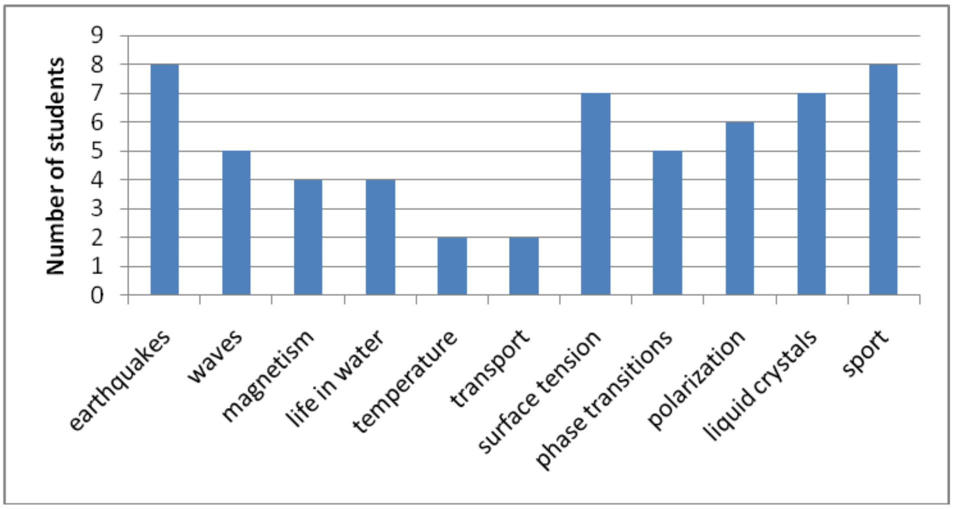


Figure 5 Topics that students found especially interesting. They were allowed to quote multiple topics.

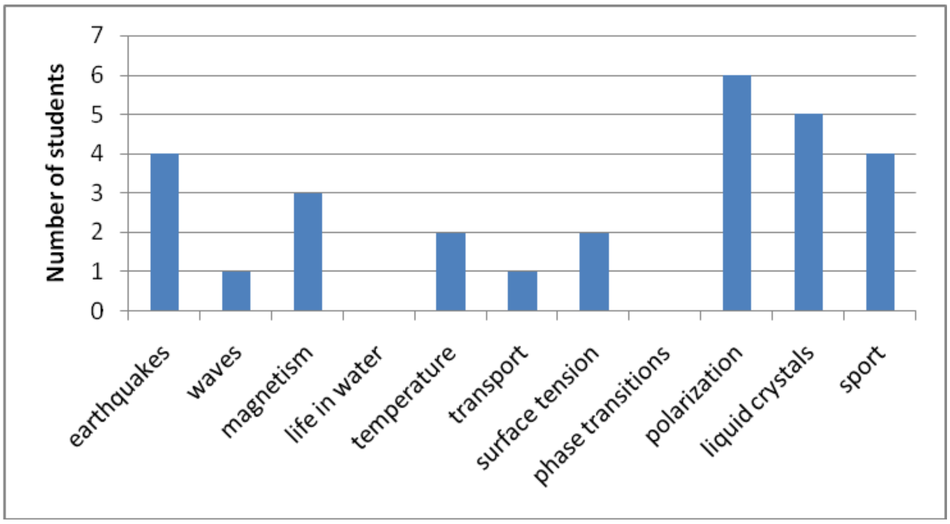


Figure 6 Topics that the students found less interesting. They were allowed to quote multiple topics.

CONCLUSIONS

The new course Physics and nature discusses a variety of different topics. Most of them need a thorough knowledge of physics and math for the correct and detailed comprehension. However, according to our opinion, we managed to present the topics, problems and some contemporary scientific questions at the conceptual level where only very basic pre knowledge in physics was needed. Each topic from the course can also serve as a popular lecture to increase the awareness of public for natural sciences.

The results of the exam have shown that students have acquired many concepts which they will be able to grasp in more depth in the later years of their physics education. They have also reported the subject as interesting and motivating which is seen by their appreciation of different topics.

In addition, as the prerequisite for the subject and its topics was not the in-depth knowledge of physics, the topics prepared and tested may be introduced to the high-school curriculum as well.

ACKNOWLEDGEMENTS

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UNDERSTANDING TEACHER PRACTICE USING THEIR OWN NARRATIVES

Peer S. Daugbjerg

The Department of Education, Learning and Philosophy, Aalborg University

pd@viauc.dk

ABSTRACT

This paper discusses ways of understanding teacher practice in educational settings. An educational setting consists of cultural, social and historical elements that all influence the teacher's practice and, how she experiences this practice. It is argued that teaching science and technology is a socially conditioned practice. The teachers' practice are formed by their previous education and experience but also influenced by their private life. This way of looking at teacher knowledge and experience requires attention to teachers' perception of these aspects. Teachers seldom talk about their knowledge of teaching, but they willingly tell their experiences from being a teacher. Therefore it is argued that narratives and life history of teachers can give insight into teachers experience, knowledge and practice. The notion of habitus is used to merge the former experience with the actual practice.

The paper discusses pitfalls and steppingstones in the process of using narratives to understand teachers' experiences and knowledge. Important steppingstones are few questions, teacher written contributions, careful analysis and supplementary collection of observations. Important pitfalls are ideologism, psychologism, exclusion of teachers' perspective and lack of distance to practice. Pitfalls and steppingstones will be illustrated in relation to narratives of Danish science teacher.

Keywords: *Teacher practice, habitus, narrative inquiry, life history, pitfalls, steppingstones.*

WIDENING THE PERSPECTIVE ON TEACHERS' PRACTICE

Teacher practice is composed of many different work functions, where teaching is predominant, others being dialogue with colleagues, principals and parents. Characteristic for all of them is relations to other humans; teachers are therefore constantly engaged in social relations.

The Danish male teacher Knud puts it this way: "*You have to like humans. That is rather important; if don't like humans, if you don't want the contact with other humans, then it probably is a foolish choice, then it is a foolish profession to enter."* I met Knud during a series of life history interviews conducted in the western part of Denmark close to the North Sea. At an age of 40 Knud had been a teacher for 9 years. Knud is a former fisherman, after 10 years of fishing on the North Sea he started taking higher preparatory courses; afterwards he entered the teacher education and became a teacher. Knud was replying to the interviewer's question of whether everybody could be a teacher, this question was posed when they were talking about what it takes to be a teacher. Knud's mildly ironic phrasing of his answer is characteristic for the understated use of speech language is this part of

Denmark. You never exaggerate and you seldom address critique directly. Being aware of this local nuance of spoken language it is easy to see his main point, the deciding factor in the teaching profession is the relations to other humans.

Roth (2002, p. xv) describes how his detailed knowledge on a pupils short-term knowledge didn't help him in understanding the learning difficulties that a particular pupil was facing upon the death of his aunt. His uses this example to illustrate the awareness that he developed when returning to teaching after finishing his doctoral study on pupils' short term memory and learning in science. He realised that theories on the reflective practitioner by Schön (1987) or pedagogical content knowledge by Shulman (1987) didn't describe his teaching practice in its complexity; they all just described parts of it.

These two narratives from actual teaching practice illustrate the social skills teacher have to posses in their relation with other humans in their daily practice. Researcher of all types needs to be sensitive to these and other elements of teachers practice in research in science education. Roth (2002, p. 21) adds a critique of mono-theoretical approaches to education research, which raises questions on how to gain insight in what really matters to teachers in their practice and how to research this. Roth (2002) points to the fact that awareness of details in an educational setting can lead to focus on the significant detail in an actual teaching situation. Roth (2002) was in the actual case acting as a teacher-researcher observing and reflecting on his own practice, but this observation and reflection could also have been done by an academic researcher in dialogue with the teacher. The point is to get the story with the boy in learning difficulties told in its entirety. So by starting with sampling what is present in the classroom we have a better chance for getting back to what is actually the problem.

A Danish female primary school teacher – Helle gives a characterisation of teachers' work, which reflects Roth's (2002) experience of the complexity of the teacher profession.

Helle: "*You must have situational awareness. It's about very fast to pinpoint what is happening here. You should be able to navigate in very many different signals, you must quickly respond to it. Situational awareness is what you have to possess. Then you have to multitask, it's nice seeing that I do not get stressed out by it, damn there may be many things at once. Can't you multitask then ... I have contact to some of my classmates from the teacher education, which some of them have already left the teaching profession because they can't. It is because there is too much going on."* Roth (2002 p. 21) formulates the same experience as follows: *"I noted that in becoming a teacher, there was a development in my capacity to do the right thing at the right moment"*. I met Helle during the formerly mentioned life history interviews. She had only been a teacher for 4 years despite her age of 43 years. She has worked 15 years as an industrial worker. Her last employment was at a male-dominated window assembly plant. She suffered a work injury and had to be rehabilitated. She chose teaching as her new career. The years of working at industrial plants shaped her approach to relations with others: *"I have a sharp tongue and the parents learn that is the way I am."* Helle's former lived experience forms her relation to the parents and her present lived experience of teaching add to these embodied experiences and shape her notion of teacher practice. I shall return to such embodied experiences later.

Jacobsen (2004 p.15) discusses ambiguity using Ziehe's writings on youth culture. Ambiguity is increased in the contemporary society, but it also gives great satisfaction being able to cope with it. Helle's narrative above illustrates this point by giving a picture of the awareness on details and ambiguities in the teaching situation among the teachers' we met. Such an awareness we academic researcher also have to develop in order to provide recognisable pictures of science teaching back to the science teachers. Carr (2006) discusses educational theory and its relation with practice, he emphasises in his conclusion the need for practical justification of educational theory (ibid. p. 155). Roth (2002. p.21) joins this view as he says "*I believe that the ultimate test of theories is the capacity to explain subjective human experience"*.

UNDERSTANDING TEACHER PRACTICE USING KNOWLEDGE AND EXPERIENCE

Research on science teacher practice is conducted by both academic researcher and by science teachers. Science teachers own research provide an inside perspective on science teaching practice, whereas academic researcher provide an outside perspective. Both approaches have benefits and pitfalls. Inside perspectives are often very true to the context with the advantage of providing direct improvement to the actual practice, but being without value in other contexts. Outside perspectives tries to decontextualise the developed knowledge in order to make it valuable in shifting context, a process that renders it of less value in the context where it is developed (Roth 2007, Jenkins 2000).

Many investigations focus on development, change and intervention, very few deals with analysis or description of the actual status. This renders the departure point for development and intervention uncertain. Therefore the following improvement and its direction is sometimes blurred (Hewson 2007).

Roth (2007) reviews the approach of science teachers as researchers. The majority of these studies are conducted during part of pre-service and in-service teacher education or professional development. The research is often part of the assessment of changes in practice generated by these interventions. Roth (2007) states that high-quality inquiries and analyses should prompt teacher researchers to develop new understandings that have implications for his or her teaching and improve students learning (ibid. p. 1241-1242). She recognizes that it is a high bar to hold up. She presents no reflections on where in their teaching career the involved teacher researchers might be in relation to their capacity or motivation to make such improvements. Hewson (2007, p.1200-1202) notes in his review of science teacher development, that it is not possible to paint a coherent picture of the best way to perform science teacher development. He summarizes his findings in a 3 step model 1) define starting point, 2) define end point and 3) the ways they might be connected. Combining these two notions of development it would seem fair to include attention to teacher experience and work conditions in the 3 phases suggested by Hewson in order to increase the ownership of the developmental process.

Tsai and Wen (2005) gives a quantitative review of the content of research presented in three leading journals, they analyse 802 papers. They find that 7% deals with Teaching, which is the category that includes teacher thinking, behaviour and strategies along with teacher knowledge. This indicates that teacher knowledge and teacher experience is not a dominant research field in science education at the moment. Contemporary international research in science teachers' professional development is reviewed in the Handbook of Research on Science Education edited by Abell and Ledermann (2007). These reviews show that the research has its primarily focuses on individual teachers' knowledge, attitudes and beliefs. The notion of teacher knowledge has several prominent theories such as Pedagogical Content Knowledge (PCK) and Subject Matter Knowledge (SMK).

PCK is often presented as an integrative approach to the science teacher profession (e.g. Gess-Newsome and Lederman 1999, van Driel et al 1998), that weaves together different representations of experience. The PCK tradition prescribes experience and narrative accounts to be processed in order to serve as basis for learning or development. The intention of collecting narratives in this tradition serves a larger purpose namely the description of the PCK of the individual teacher. This individual focus might lead to superficial analysis of the narratives. Teachers' knowledge on science and technology or on science and technology education does not provide the full picture of how they perform their work as teachers and how they understand this work.

Teachers in the school are not isolated islands; their professional knowledge is socially conditioned. Kosonen and Houtsonen (2007) explore this point by using the Bourdieu notion of habitus. The interaction with the pupils is influenced by a lot of other factors, that Kosonen and Houtsonen summarizes in the habitus of the teacher. They state:

"Their [the teachers] habitus are formed by past practices in different settings, especially, in their professional education and training, in their work and career, and also in their personal lives" (Kosonen and Houtsonen 2007, p.172). Roth (2002, p. 45) describes habitus in an educational setting as "*the patterned ways in which we interact with the world, including those practices that embody actions, perceptions and expectations."*

This way of looking at teachers' knowledge requires attention to their perception and appreciation of their own experience and knowledge and how they see this in relation to colleagues and pupils. Helle and her sharp tongue is an example of how past and present experiences merges to form a coherent notion of a practice. I will use this notion of the habitus as embodied experiences to summarize my main points in the conclusion.

This insight in teacher understanding of their practice is brought forward by the use of a teacher's own language about her own practice. Jenkins (2000, p. 21) summarizes his health check on research in science education by stating: *"Is it perhaps because the research community fails to grasp the complexity of teaching science or lacks an adequate indigenous pedagogical language and conceptual structure with which to capture what really matters about teachers' work? … It isn't simply that the existing language fails to capture the essence of what teachers do when they teach science. It can also present a seriously mis-leading picture of what is involved in teaching."*

Roth (2007) quotes a few studies that argue for rising the teachers own voice in science education research (ibid. p. 1236). This indicates that it is not a very strong tradition in science education research. Furthermore teachers seldom talk about their knowledge of teaching, but they willingly tell their experiences from being a teacher. Lortie (1975 p. 77 ff) and Müller et al (2007 p. 4) has interviewed teachers. Their findings furthermore point at experience as being the significant mode teachers learn teacher practice. Perhaps we as academic researcher should lend more ears to the narrations of the teachers when they are talking about science education in order to understand the experience and knowledge at play in science teaching.

NARRATIVE RESEARCH STARTS FROM THE TEACHERS OWN LANGUAGE

The use of narrative inquiry in creating an understanding of the work conditions of science and technology teachers is an inclusive approach that unveils details and ambiguities. As discussed earlier details are important in order to understand the complexity of teaching in its entirety. The narratives about the context of teaching from Roth (2002) and the informant

Helle presented earlier illustrates the contribution narratives give to understanding which detail to focus on in the actual situation. A given narrative contains many opportunities for interpretation but the relevant one can only be chosen through simultaneous understanding of the context of the school, including pedagogical trends, colleagues, curricula and ongoing reform processes (Elbaz-Luwisch 2007). In this process of understanding the context of the teacher's work it can be beneficial to include some aspects of the life history of the teacher (Goodson 2008, Clandinin and Connelly 2000) as illustrated by the way the informant Knud talks about being a teacher.

An example of presenting interesting stories of teachers is the cohort study by Goodson and Numan (2003) on a class of Swedish teachers who graduated in 1960. These stories tell about the changes in the Swedish primary school over a period of 40 years. Many interesting aspects are raised by the teachers, but the presentation given by the authors lack exhaustive analysis of the circumstances and contexts that might have extracted knowledge of more general interest from this impressive material. A want the authors themselves are aware of as they promise to provide (ibid. p. 228) this analysis in a later publication, unfortunately this publication is still lacking. The details and ambiguities is overwhelming in such a large set of data, therefore you need to choose a theme that you want to focus on – it can be how former life experiences can form the teacher in their relation to pupils and parents as given by the examples presented from my own life history interviews, or it can be becoming a science teacher (Roth 2002).

Clandinin and Connelly (2000) stress that narratives are the best way to get teachers experiences verbalized. A narrative includes interpretation, reflection, history, environment, relations, ontogenesis and exclusion of experiences. It is not an accurate and true version of the teachers' past but a recollection of past experiences recreated in the dialogue with the researcher.

Narrative interviews

Kvale and Brinkmann (2009) give detailed guidelines on how to perform different types of interviews. They stress that the narrative interview focuses on the stories the informants tell as well as how they tell them. The narratives are the fundamental given data in this type of research. The narratives are either told freely or the interviewer helps constructing them through questioning the informant. It is important that the interviewer clarifies details in the storyline, so that conflicts, solutions and tensions are formulated by the informant. Researchers affect the participants. Their questions start reflection and development among the participants. The narrative emerges in the dialogue between participant and researcher; it does not exist prior to this dialogue.

Herman and Vervaeck (2005) present the main characteristics of structuralism in their *Handbook of Narrative Analysis*; they distinguish between the Narration, the Narrative and the Story. The Story includes events and presents the characters involved, the Narrative gives the timeline, details about the characters and the focus of the story finally the Narration is the actual dialogue – the spoken words – and actions between the characters. This distinction between the elements in a story is good structuring tools in the process of selecting relevant details for further analysis.

Life history

Bruner (1984) defines a life history as: *"A life as told, a life history, is a narrative, influenced by the cultural conventions of telling, by the audience, and by the social context".* Goodson

(1992) distinct between life story and life history, his notion of life history is in accordance with Bruner including contextualisation; but he introduces life story to describe life as told as merely the story without elaborate inter-contextual elements developed by the researcher.

The researcher arranges the narratives in chronological and contextual order to create a coherent life story. This life story is related to essential historical events regarding society, school, science and science education creating a life history of the science teacher. This work involves an analytic and interpretive process where the researcher is looking for harmony and interaction between teachers narratives and experiences on the one hand and on the other hand the historical context. In this process the researcher sensitivity towards the teacher's life and the evolution of the society is essential to avoid intimidation of the teacher.

Clandinin and Connelly (2000) stresses the importance of this part of narrative research, they describe it as composing a research text based on the interviews. A research text includes the story of the researcher in the inquiry, the story of the participant and the larger landscape on which they all live. Clandinin and Murphy (2009) further elaborate this point of view as they state that the research text speaks to 3 audiences: the participants, the researcher and a larger scholarly and public audience.

The relation with the participants is of great importance, so that they remain ownership to their statements (Roth 2002). It is important to maintain the original coherence between conscience and the historically lived life of the participants in order to fulfil the relational responsibilities of representing the experiences we co-construct with the participants (Clandinin and Murphy 2009).

Lortie (1975 p. 79) raises an interesting methodological problem as he writes: "*... socialization into teaching is largely self-socialization; one's personal predispositions are not only relevant but, in fact, stand at the core of becoming a teacher."* This could indicate that psychological interviews would be the best way to understand teachers' notions of teaching. Leontjev (1981, 267-271) points to the difficulties in trying to understand human activity as psychological processes. We have primarily access to the external notions of the teachers' experiences through the physical statements and utterances they produce. We do not have insight in their inner reflections unless they provide us this insight through their utterances. Narrative research is not providing psychological insight or evidence it provides narratives that can be interpreted in relation to relevant historical, cultural and social conditions. Clandinin and Connelly (2000 p.50) describe dimensions for analytical handling of these conditions. They first describe inward, outward, backward and forward directions of experience. The inward direction relates to feelings and moral dispositions. The outward direction relates to the environment. The backward and forward directions relates to time. They condense these 4 directions to 2 dimensions one dealing with inward-outward and one dealing with backward-forward, then they add a third dimension space, that deals with the landscape of inquiry. I would like to sharpen their definition of these dimensions. I see one dimension dealing with the time line of events and experiences, another one dealing with the educational settings of the events and experiences and a third dealing with social and personal relations of the events and experiences. This is in agreement with Goodson (2008) who emphasizes the importance of relating the personal teacher story to the more general history of changes in the school. Furthermore the coherence between the time and the settings dimensions can be analysed using Bakhtin's notion of chronotope (1981, p. 84), this notion grasp the interplay between time and space in narrative analysis and inquiry.

HOW CAN NARRATIVES CONTRIBUTE TO OUR UNDERSTANDING OF TEACHER PRACTICE?

In following I will present yet another teacher from the life history interviews conducted from January to March 2009. I will give a more extensive introduction to him in order to shed light on his handling of a difficult teaching situation.

Jesper (male 53 years, 24 years as teacher) grew up in a village in the western part of Denmark near the North Sea, this part of Denmark is called West Jutland. He was originally trained in trade and office in a larger town 15 km from his birth place, after finishing this training he worked in an engineering company in a larger town on the east coast of Danish peninsula Jutland for 2 years. He finds the work boring, so he moves back to his birthplace in West Jutland. The story of Jesper entering the teacher profession is interesting as he moves back from the more densely populated east coast of Jutland to take a teacher education and work locally as a teacher subsequently. This move back west is unique; very few people who have left the western coastal region moves back again. His upbringing in West Jutland retracts him to this part of the country. The teacher education is one of the few available higher educations in the local area. Jesper had already after finishing high school considered becoming a teacher, but due to family tradition he chose otherwise in the first place. A choice he later regretted and returned to become a teacher "back home".

Jesper teaches primary science and mathematics. Jesper describes the problem with large class and the need for differentiated teaching.

"Now we have classes that are huge, so it was no way the way I thought it would be. We did not know initially that they would be so big. In mathematics, it is not possible to do practical work. I've tried dividing the class, and then take care of one half and then have the other half do something themselves. It's not a solution, I tried it 3 times and then I went back to having the entire class together. Of course you have a lot of different activities and they work in groups. Many changes to give variation to the lessons, but they are always under control, because those who do not want to do something. You always have to keep an eye on them. It is rather difficult, but goes fairly well."

"There is a teacher's aid here, she should be in every Friday in the 2nd module, but she has not been there yet because either she has been sick or she has been set to do other practical chores here at school. Today I came and had again planned and duplicated ten sheets she had to work with 10 vulnerable pupils who actually just is being fobbed off, as we can not get at them because there are too many, then I will teach the 20 who can and will on their own. You know it's not something we hide. It is somewhat sad to see a group that is falling through. It has been reported to the office many times. I've had the headmaster down a few times because she has to see it. She says it is such an ordinary working situation. I can not expect to get them all to work, but it is a big group that never has any benefit of the teaching"

"On the other hand, when they are divided in small teams in primary science it works well, and you will learn to know the pupils much better."

This report describes a teacher with a professional dilemma of wanting to do more than he can overcome on his given conditions. Jesper know he can make a difference to more pupils if he had other conditions for his work. The context is a small rural school with only 30 pupils at this year level. A division into two classes will cost the school more hours to be paid to the teacher, which then will reduce the economy for the entire school as it is paid per pupil not per teacher work-hour. In order for all pupils to achieve well in mathematics the right thing to do professionally would be two minor classes, but this collides with the economic conditions given this school in a rural area of Denmark. In an international perspective class with 30 pupils are not rare, but this is not relevant in the actual case where the teacher experiences that he is not able to differentiate detailed enough to reach all his pupils. His frustration on the situation in the mathematics class is also affected by the fact that in the integrated primary science class he has the class divided into 2 teams of 15, and here he experiences, that all the pupils participate and contribute to the learning in the classroom. So he knows that all the pupils can be reached but his conditions for doing this are different when he teaches the two subjects. The story illustrates the cultural and social conditions that govern his possibilities for teaching according to his personal and professional optimum.

Jesper has deliberately chosen the teacher profession in this part of the country after trying something else. His devotion to the teaching profession and the well-being of his pupils is uttered in a low voice, because he also realises that the economic constraints put on the school can't easily be changed. Despite his frustration there seems to be established a harmony between the teaching profession and the attachment Jesper has to the local area. Muel-Dreyfus (1983) talks about this harmony between humans and professions, she states that*: "People choose a profession and the profession makes them it's chosen ones."* Roth (2002) would with Bourdieu say that Jesper's habitus is to deal with these conditions without making a big fuss of it.

In this example of interpretation of a teacher narrative I have included my general knowledge of the local area. I have managed to get Jesper to tell a coherent story about a part of teacher work that worries him. I lack making observations of his teaching in order to get a more detailed understanding of the problems he is telling about.

These things would improve my foothold in walking in the landscape of teaching science and mathematics in a rural part of Denmark

My intention has been not to prescribe either psychological or theoretical explanations on Jesper's story and I have tried to stay close to the perspective Jesper present. My intention has though been to avoid ending in a pitfall of practice from where the applied reflections would lack a general overview of teacher practice. I have aimed at giving primarily sociological explanations of the narrative.

Not every aspect of narrative research can be illustrated from a single example, but some of the qualitative benefits and points of caution can be presented.

Steppingstones working with narratives

Combining my own experience with recommendations from Ivor Goodson (see e.g. Goodson 2008) some steppingstones can be formulated for the work with narrative research:

Ask few open questions – like these*:*

- Tell about your childhood and home?
- Tell about your teenage years and schooling?
- Tell why you chose teacher education?
- Tell about how you plan and perform your teaching?
- Tell about what the next development move is going to be?

Make the teacher write: About a limited number of significant episodes, in their teacher career.

Make supplementary interviews and observations: After analysing the collected material it can be necessary to collect further narratives, information's or observations in order to have a rich understanding of the life history.

Keep open for the personal voice of the teacher: Teachers can be exaggerating in order to promote themselves, they can be understating as an ironic distance or in order to appear as victims, they can be objective leaving little space for their personality to show or they can be empathic focusing primarily on the relations to the students and colleagues.

Make detailed analysis of the utterances: This extracts more knowledge from the narratives by 1) analysing for intonations and pauses (see Roth and Thom 2009) or 2) linguistic analysis see Herman and Vervaeck (2005).

Analyse for what matters in teacher practice: The analysis can proliferate from looking for the 3 significant teacher competences identified by Nordenbo et al (2008):

1) Teacher relation to the individual pupil – social relation competence;

2) Teacher relation to entire class - competence to make class rules and support pupil autonomy;

3) Didactics and subject matter competence.

Pitfalls working with narratives

The process of interpretation and contextualisation contains several chances to trip over blind spots and dwell comfort zones. It is important to be aware of these in the process of creating a true and valid life history. The following list is inspired by Elbaz-Luwisch (2007) and my own experience:

Beware of ideologism: The teacher's life history is unique, it is not the entire truth about science teaching, and it does not serve a politically correct agenda within education or research. Bourdieu (1999) provides reflections on how to grasp the social conditions of which informants are the product.

Beware of psychologism: Narrative research is not therapy; it tries to understand not to cure. Leontjev (1981) gives guidelines for a dialectic approach to reflection and activity. Husserl (1999) advocates for a phenomenological reduction in order to start with the immanent and observable given facts.

Beware of causalities: The interpretations shall qualify relations, causes and actions with care and empathy for the teachers work conditions and private life.

Beware of excluding the teachers' perspectives: The teacher can have mixed motives for their choice of career and their mode of teaching.

Remain critical towards practice: Narratives interviews are collected in an atmosphere of confidence, this confidence can become a blind spot in the interpretation process.

CONCLUSION

The 3 teachers you have met in this paper all have changed to the teacher profession after years of other work. They all have a sharp focus on the main work function in the teacher practice – teaching. They clearly have become teacher. Their habitus has changed from their former careers to the teaching profession, in this change their former experiences have been supplemented with new experiences. They consolidate their present habitus by giving clear statements on central aspects of the teaching practice. Given the opportunity to tell about their experiences with the teaching profession they all do this in a committed manner.

In the article I have been trying to illustrate the qualities of narratives in providing insight in teacher practice. I have theoretically positioned narratives as a significant element in teacher practice research because it contributes with the teachers' perceptions and experiences of their own practice. Narratives construct the past in the present. Narratives give a language to teachers' disposition for doing their job. The teachers' dispositions are structured by their past and are structuring their presence and future.

To understand teachers we need to know their history and how they have experienced it. This is the basis for their present teaching and for their potential to develop their teaching. The history of teachers is more, than is normally assessed by looking at their knowledge on pedagogue and subject matter. I do not reject that assessing teacher knowledge can contribute to understanding their practice. I only say that using narratives unveils subjective understandings that are close to everyday teacher practice.

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TESTING THE TEST: WHAT CONSTITUTES SCIENCE IN THE BRAZILIAN HIGH SCHOOL (ENEM) NATIONAL TEST

Everaldo dos Santos

Paraná State Educational Board, Brazil

everaldosant@hotmail.com

Christiane Gioppo

The Federal University of Paraná, Brazil

cgioppo@yahoo.com

ABSTRACT

This study analyzed a Brazilian High School Test called ENEM. The test was first used in 1998 and assesses High School students' knowledge according to the Brazilian National Guidelines (PNLD). Our goal was to compare the reference test matrix and the proposed questions of 2007 and 2008 with the four Science Education strands delineated at NRC report (2007). We also compared matrix and questions with Anderson and Krathwohl (2001) Taxonomy for Cognitive Domain. Results of NRC/ questions comparisons show that most questions followed only one strand that focused on the content - not on the processes of science, its history, or inquiry. Results for Taxonomy/ questions comparisons revealed the test is prepared primarily with low level reasoning questions. Conclusions indicated the test does not evaluate whether students gained a broader perspective of science, and how science works. Thus, even if the test does not focus only on memorization of information, it is very difficult to discuss what science really is, and how explanations and models are built. There is a lack of questions on the processes of science, on the history of science and on inquiry that could generate an interpretation of the nature of science among pupils. Additionally, if we understand that the test is used nationwide and is able to change policies in Education, policymakers should look carefully to what strands are missing and how the test can effectively evaluate science understandings.

Keywords: *Assessment, Science Education, High School.*

INTRODUCTION

In Brazil there is a high school National Test called ENEM. This test is used nationally and has grown increasingly significant among students, high school teachers, and the college policymakers who decide university entrance policies. It evaluates not only students Knowledge from different High School subject areas but also indirectly the Brazilian Educational Systems. In 2009, the Brazilian Ministry of Education proposed to university policymakers that they adopt the Test as a component of the students' entry into College. There was much criticism particularly regarding the interference of the National minister in the issue of university autonomy. Despite the criticism, many public universities decided to adopt the test as one part of the grade. Faculty members checked the test and complained about it. The main argument used against ENEM is the test is too broad and shallow to evaluate students' knowledge and should not be used as a university entrance tool. This paper will discuss this dispute.

The questions are prepared based on a reference matrix which structures the test. The matrix includes five competencies and 21 abilities considered essential to the students on this level. The test has 63 questions (3 for each ability) and there is no distinction among courses or disciplines, thus questions may present concepts related to more than one subject area of school knowledge or presented in any high school course. Knowledge about Natural Sciences is presented in questions that sometimes are not evident to evaluate scientific knowledge. Only after a careful reading is it possible identify the scientific knowledge being tested. The intention to ignore or to clearly evaluate scientific knowledge is presented only in competencies One and Two. Competency One suggests that the student should have "Comprehension of the Portuguese language norms to use math, artistic and scientific languages" (MEC, 2008). Competency Two indicates the need to "construct and use concepts of many subject areas to comprehend natural phenomena, historic-geographic processes, the technological production and the artistic displays (MEC, 2008).

Considering the reference matrix is based on competencies and abilities that all students should have, we understand that ENEM test is not only a high school exam but also a policymaker on the public and private sectors of education. We will also address in this paper, an analysis of questions presented using Anderson and Krathwohl, (2001) revised taxonomy for cognitive domain.

In Brazil, until the 1990s, most of the National and State tests of different grade levels were based on Bloom's taxonomy (1956). Typically, only three basic levels of the Taxonomy (knowledge, comprehension and application) were used on the reference matrix. After that, The Paraná State Board of Education suggested that a matrix based on Bloom's taxonomy should be replaced by another one using attitudes, process skills and conceptual approach (Coll, Pozo, Sarabia and Valls, 1998) to assess students However these names were not used, instead the matrix used Basic, Operational and Global levels of questions.

When the ENEM test was created its designers preferred using the idea of competencies and abilities to outline the new matrix. ENEM test reports and documents stated clearly the intention of matching with the National Guidelines, also based on Competencies and Abilities. Designers argued that students should be able to analyze real situations and be able to react to that. Macedo and Lopes (2002) criticized the national Guidelines and the very idea of competencies and abilities. They pointed out the differences between scientific and school knowledge, showing that school knowledge is organized to be taught. This organization is a sort of pedagogical filter that has a cultural framework and guides the content selection beyond the epistemological criteria.

Krasilchik (2000) studied the history of Science Education in Brazil and emphasized that, educational policies such as the Brazilian Guidelines for Education (and ENEM test) have intentions related to the social, historical, political, economical, and cultural moments. She argues that all these issues influenced more the design of Brazilian Guidelines (and nationwide tests) than the scientific production itself.

Thus we identified at least two tensions. The first is related to the scientific knowledge versus school science knowledge selection. What should be taught and then assessed in a high school nationwide test? The second tension is related to the idea of competencies and abilities as a guideline for Science teaching and learning. Are the tests addressing the major issues of the Natural Sciences?

To address these tensions we looked for studies that tried to see the big picture and give some orientation for Natural Sciences textbooks, curriculum or guidelines.

The US National Science Education Standards – NSES (NRC, 1996) framed eight categories for content standards: unifying concepts and processes in science; science as inquiry; physical science; life science; earth and space science; science and technology; science in personal and social perspectives; and the history and nature of science.

Years before, Yager and McCormack (1989) proposed six domains for School Science Programs: concept; process; creativity; attitude; application; worldview. Yager also actively participated on the preparation of NSES standards. Recently he proposed an interaction of the six domains with the Assessing Science Learning (Yager, 2010). His proposal is summarized on Figure 1:

Figure 1: Interaction of the six domains for teaching and assessing Science Learning.

Concept Domain Process Domain	The typical focus for traditional teaching (i.e. basic science concepts and skills)
Creativity Domain Attitude Domain	The two enabling domains (i.e. questioning & personal/ social engagement).
Application Domain	Using concepts and processes in new contexts (i.e. living in the whole world with use of science as defined by NSES)
Worldview Domain	Examining the philosophy, history, and sociology of the whole science enterprise (i.e. where most people live and operate when not engaged with science directly)

(Note: framework designed by Yager, 2010, p.11)

Chiapetta et al (1993) focused on science textbook evaluation and proposed four aspects of scientific literacy: a) Knowledge of Science; b) the investigative Nature of Science; c) Science as a Way of Thinking; d) Interaction of Science, Technology and Society (STS).

More recently the US National Research Council (NRC, 2007) prepared a report for Science Education that point out four strands to be proficient in Science.

> Students who are proficient in science:
>
> 1. know, use, and interpret scientific explanations of the natural world;
>
> 2. generate and evaluate scientific evidence and explanations;
>
> 3. understand the nature and development of scientific knowledge; and
>
> 4. participate productively in scientific practices and discourse. (p.36)

These strands were used in this study to evaluate the tests and its matrix. Our main goal was to compare the reference test matrix and the proposed questions of 2007 and 2008 with the four Science Education strands delineated at NRC report (2007).

METHODS

This study was a document analysis of the Brazilian National high school Test (ENEM). Initially we analyzed 2007 and 2008 tests comparing them with their own matrix. After that we compared the test and its matrix with the four strands presented at the US NRC report (NRC, 2007)

We decided to use the NRC (2007) as a basis for this analysis because we understand that this report compiles many studies on the area and identify issues that are also important for Brazilian students.

As for the tests and matrix chosen, we used 2007 and 2008 because the matrix and test for 2009 changed and part of the test is now more related to subject areas, thus in order to compare tests and matrix to the strands, we preferred using previous years.

After using NRC (2007) report to categorize test matrix and questions, we also used Anderson and Krathwohl (2001) Taxonomy for cognitive Domain. These authors reviewed Bloom's taxonomy (1956). Even considering Bloom's taxonomy dated for Science Education, we have to agree that most tests all over the world are still based on it, especially the ones related to the cognitive domain. In this study we wanted to check if ENEM test was, in fact, based on competencies and abilities as it is supposed to be or if competencies and abilities would be in fact only a make-up for Bloom's taxonomy.

RESULTS AND DISCUSSION

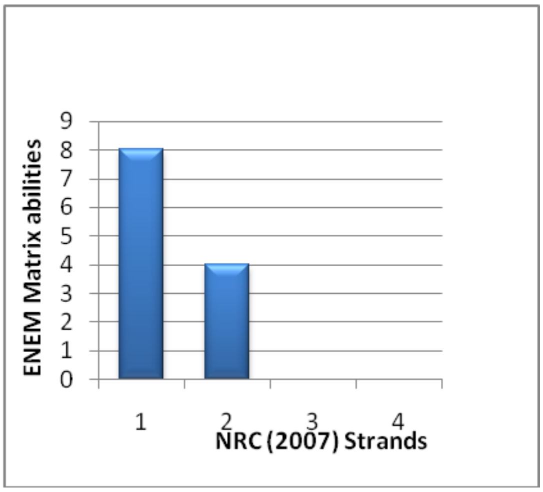
Matrix Analysis:

The intention to evaluate scientific knowledge is formalized on competencies I and II. Competency I suggested that students should have "dominium of Portuguese Language norms and the correct use of other "languages" such as mathematical, artistic and scientific (MEC, 2008). Competency II indicates the need to "construct and apply concepts in many different subject areas to understand Natural phenomena, historic and geographical processes, technological production, and artistic issues" (MEC, 2008).

Looking at the test matrix and its competencies it is possible to infer that ENEM is being used not only as a regular test but it also intends to be a guiding principle that affects policies and policy makers in a public and private sectors of Brazilian education. Furthermore its influence is growing since its results are now being used as a method for entering the university. Test questions present different ways to assess students' cognitive domain (Anderson and Krathwohl, 2001) and guide a conception of Science Education.

On the other hand, the division in competencies and abilities of the ENEM test matrix is one dissonant point with the actual Paraná State Standards (and also many other state standards) because the State Standards were created based on disciplines and ENEM matrix and test is not. Paraná state Educational Board is reluctant to accept the idea of competencies and abilities and formally mentioned that teachers should not base their class plans on that. Figure 2 shows the relation of the matrix abilities with the NRC (2007) four strands.

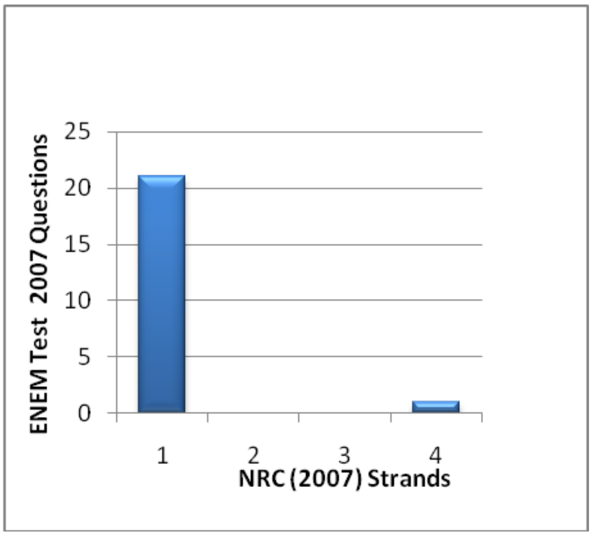
Figure 2: Relation between matrix abilities with NRC (2007) four strands.



Tests Analyses:

Considering that the abilities are not subdivided in disciplines we had to select the ones that referred to the Natural Sciences. In order to select and categorize abilities we looked at them and then checked the tests and test reports. We also checked levels of reasoning following Anderson and Krathwohl (2001). The chosen ones can be categorized into two NRC Strands: 1. know, use, and interpret scientific explanations of the natural world; and 2. generate and evaluate scientific evidence and explanations. On the first strand are abilities that needed the comprehension of scientific concepts, principles, theories, and to understand natural phenomena. On the second strand are abilities that can somehow be related to data analysis and inquiry, even if the inquiry is limited to data analysis on the questions. No abilities were included on the categories 3 and 4. It means that there were no relation to the History and philosophy of Science and also no relation to the social use of scientific knowledge. Figure 3 presents number of 2007 ENEM test questions related to NRC (2007) four Strands.

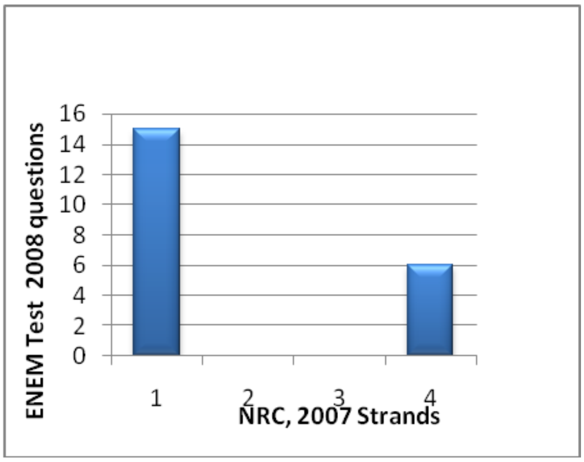
Figure 3: Questions of ENEM test 2007 test related to NRC (2007) four Strands.



Most questions somehow related to scientific knowledge on 2007 ENEM test are on Strand 1. These questions mention scientific laws, theories and concept knowledge to understand a phenomenon. There was only one question on Strand 4, related to discourse practices and the social use of scientific knowledge. It is interesting to note that there was no ability directly related to this strand but it did appear in one question.

As for 2008 questions results showed that two thirds were also categorized as Strand 1 but we could see that there are more questions related to discourse practices and the social use of scientific knowledge. In this case the questions of strand four were related to environmental issues. Figure 4 shows the number of questions on ENEM test 2008 related to NRC (2007) four Strands.

Figure 4: Questions of ENEM test 2008 related to NRC (2007) four Strands.



According to the National Research Council (NRC, 2007) it is important to teach Science because

1. Science is a significant part of human culture and represents one of the pinnacles of human thinking capacity.

2. It provides a laboratory of common experience for development of language, logic, and problem-solving skills in the classroom.

3. A democracy demands that its citizens make personal and community decisions about issues in which scientific information plays a fundamental role, and they hence need knowledge of science as well as an understanding of scientific methodology.

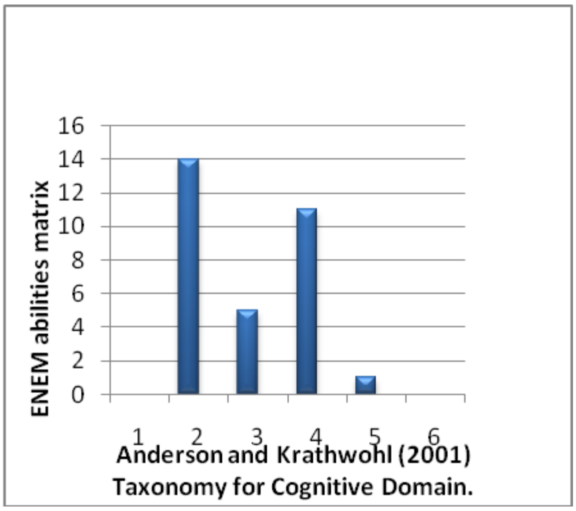
4. For some students, it will become a lifelong vocation or avocation.

5. The nation is dependent on the technical and scientific abilities of its citizens for its economic competitiveness and national needs. (p.34)

If we consider that most of the questions are related to only one strand we can infer that the test is not able to address all the needs for Science Education and citizenship and this is the most important issue of this analysis.

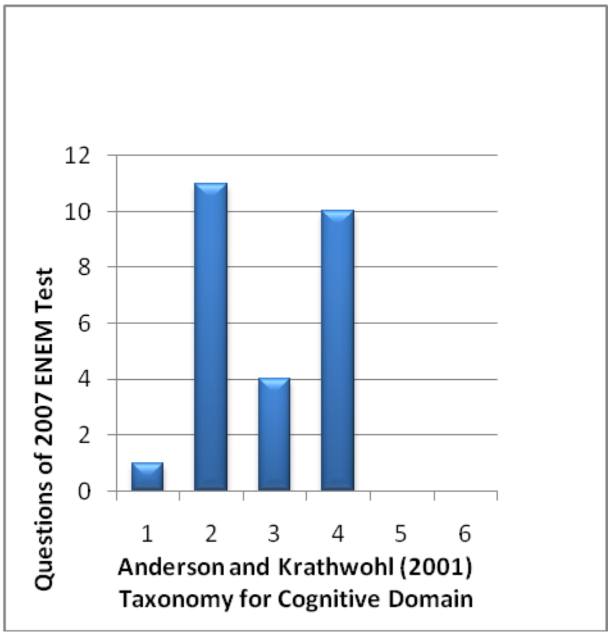
As we mentioned before, besides the NRC report (2007) we also used Anderson and Krathwohl (2001) revised taxonomy for cognitive domain to categorize the test questions and the abilities listed on the test matrix. Their taxonomy considered six levels of cognition, from the less complex to the more complex: 1) remembering; 2) understanding; 3) applying; 4) analyzing; 5) evaluating; 6) creating. Figure 5 presents ENEM abilities matrix related to Anderson and Krathwohl (2001) revised taxonomy.

Figure 5: ENEM Abilities matrix related to the cognitive domain of revised taxonomy according to Anderson and Krathwohl (2001).



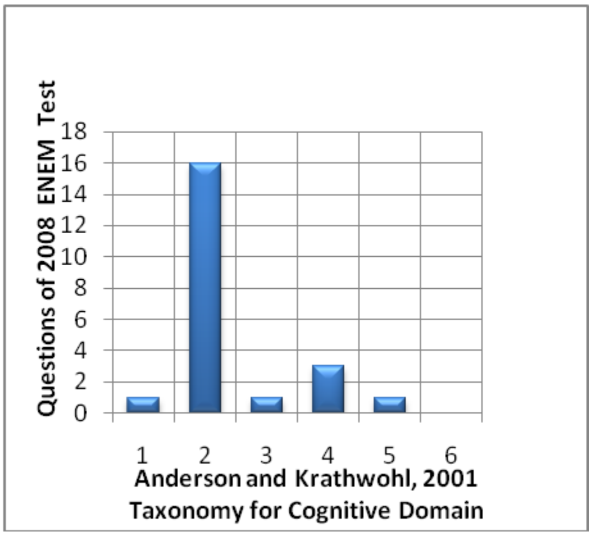
Many state tests prior to ENEM used the three basic levels of Bloom's taxonomy for cognitive domain. Our results showed that the matrix is not based on the three basic Bloom's levels since there are more than 10 questions on higher order thinking levels. Figure 6 shows 2007 ENEM Test considering Anderson and Krathwohl (2001).

Figure 6 – Questions of 2007 ENEM Test considering Bloom's Taxonomy revisited by Anderson and Krathwohl (2001)



Observe that even if the matrix presented five levels of cognition, the test itself presented only four. Level one questions did not show up on the matrix, but could be found on the test. On the other hand, level five questions appeared on the matrix but not on the test. The first level is not even considered a reasoning level, because it is only centered on information memorization. ENEM test claims it is not based on memorization, it is based on reflection. However we can see in Figure 6 that most of the questions (16 out of 26, considering levels 1, 2 and 3 of taxonomy) are distributed on the low reasoning level (Anderson and Krathwohl, 2001). Figure 7 relates 2008 ENEM test and Anderson and Krathwohl (2001) Taxonomy for cognitive domain.

Figure 7 – 2008 ENEM test considering Anderson and Krathwohl (2001) Taxonomy for cognitive domain.



As for the 2008 test, it seems that the level of reasoning is worse than the year before. It also shows that the test is not based on lower level categories of the revised taxonomy, however, there were 16 questions on the same level.

In a general sense, questions were intended to test students' reading comprehension. There were no questions to test previous knowledge, history and philosophy of Science or scientific discourses and practices. These results seem to be very relevant for Policy makers.

FINAL CONSIDERATIONS

This study aimed to investigate the Brazilian High School ENEM test. Major findings are:

- The total absence of History and philosophy of science.
- The almost non-existence of Inquiry approach of the questions.
- The lack of discussion about scientific discourse and science political view.
- The lack of correlation between test matrix and questions.
- The primary focus of the questions on reading comprehension.

This reveals that test writers should pay more attention to what is really important or fundamental in Science Education as mentioned by the NRC report (2007). Additionally, it was impressive to discover that even if the test is not following Bloom's Taxonomy (1956) or the Anderson and Krathwohl (2001) revisited taxonomy, it is clear that most of the questions are testing only reading comprehension contrary to what it should be doing. It seems National policies are not being followed by the question makers. We understand that people who are involved in test preparation should try new perspectives that could reveal students conceptions as a way to negotiate meanings among different cultural perspectives Mortimer (2004). It is our general perception that questions that test comprehension and analysis did not present a cultural perspective and this should be changed.

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SCIENTIFIC LITERACY FOR CITIZENSHIP: USING INTERLOCKING NARRATIVES AS A RADICAL PERSPECTIVE

Wildson Luiz Pereira dos Santos

Universidade de Brasília – Instituto de Química/Faculdade de Educação

wildson@unb.br

Ralph Levinson

University of London – Institute of Education

r.levinson@ioe.ac.uk

ABSTRACT

In this article, we interrogate the aims of scientific literacy for citizenship, introducing socio-scientific issues (SSI) in science lessons through 'interlocking narratives'. In the humanistic writings of Paulo Freire, dialogical action theory enables actors to co-operate in transforming their conditions, both material and metaphysical. From a Freirean perspective, science pedagogy involves consciousness-raising about social injustice, such as the large numbers of people living in landfill sites, and developing the means to transform that reality. Stories, in the form of interlocking narratives, consist of a sequence of events which enable the linking of scientific concepts to issues of social justice, economics, environmental protection and employment. We illustrate through the life-cycle of an aluminium can how scientific processes interweave with socio-political events to make transformation of life conditions possible and we give some examples of narratives found in the "Chemistry and Society" textbook. These point to both contradictions and opportunities and hence offer a means of contemplation for dialogic action. However we argue that directed teaching of political literacy is a necessary adjunct to the teaching of socio-scientific issues.

Keywords: *Paulo Freire, socio-scientific issues, interlocking narratives.*

INTRODUCTION

The Brazilian philosopher, politician and educator, Paulo Freire, is perhaps best known for his book, Pedagogy of the Oppressed (Freire, 1972). Freire's work has been hugely influential in Latin America in adult education but it also offers insights into pedagogy in developing scientific literacy in a socio-political sense (Roth & Barton 2004). Drawing his critical theory from Hegel and Marx, Freire adopts a dialectical approach towards understanding nature. As opposed to the view which objectifies consciousness, consciousness itself is moulded from reality (Freire, 1996). Through dialogue men and women can transform their conditions because words and action underpin praxis, enabling the naming of the world and providing the means for its transformation.

Some of the work emerging from Science, Technology and Science studies has much in common with Freire's analysis, particularly work which re-visions scientific literacy and raises questions of socio-political action (Hodson, 1999; Roth & Calabrese Barton, 2004; Roth & Desautels, 2002). From a Freirean analysis science education becomes endowed with a radical perspective (Santos, 2009). This perspective involves reflections on inequitable living conditions from science and technology issues related to Freire's ideas. Santos (2009) presents a pedagogy of science education which could be formulated in the following steps: (1) identifying social issues for discussion; (2) establishing dialogue in the classroom; and (3) student discussion and engagement in socio-political action (this might, for example, involve generating political pressure on the local authorities to consider alternative landfill schemes which offer decent employment and sanitation conditions.

The narrative story is a useful instrument in initiating and providing objects of reflection for dialogue. The word 'narrative' has its roots in Latin and Sanskrit, *gnarus* (knowing or wisdom) and the Latin *narro* (relate or tell). In medieval times, *joculatores*, which forms the Latin root behind the English word 'joke' and the Spanish word 'toy', were popular street storytellers; there are elements of street credibility and frivolity. Narrative conveys what is known, and can take various forms – drama, saga, story, picture, cartoon, tapestry, film, epic poem, song. As well as allowing people to tell and listen, to talk of experiences not understood or imagined by others, narrative is an organiser for these experiences by sequencing events. It can be seen as:

> *. . . the outcome of a mental process which enables us to excise from an experience a meaningful sequence, to place it within boundaries, to set around it the frontiers of the story, to make it resonate in the contrived silences with which we may precede it and end it.' (Rosen, 1987, p.13)*

The Oxford English Dictionary definition of narrative gives 'an account of a series of events, facts, etc., given in order and with the establishing of connections between them' (Oxford English Dictionary),

Traditionally narrative has been conceived as a storyline consisting of a sequence of events. In foregrounding human consciousness. Fludernik (1996) emphasizes 'the representation of experientiality' (p.28) rather than temporal sequentiality. Experientiality can include a temporal sequence of events but this is not crucial to a portrayal of narrative dynamics, what is central is that '(h)uman experience typically embraces goal-oriented behaviour and activity, with its reaction to obstacles encountered on the way' (p.29) incorporated in a three part schema of 'situation – event (incidence) – reaction to event.' But the narrator is also a reflector of experience stored as 'emotionally charged remembrance' (p.29) and therefore the narrative becomes self-evaluative and 'accountable for the actions and experiences which compose a narratable life' (MacIntyre, 1981).

A model of narrative can be construed as consisting of Fludernik's three part schema which is reflected on by the protagonist as purposeful agent (or the protagonist acting vicariously) from a moral and ethical, in other words a values, perspective.

Where there are different kinds of equal but distinct reasons for actions and decisions by contending parties, narrative allows people to relate and listen, to tell of experiences not yet known, understood or imagined by other parties. Alternative courses of action can thus be illuminated, and within settings which contain the mainstream and the marginalised, allows stories to be told where other means of communication – the judicial court, the committee of experts, the competitive debate – constrain what is recounted. Reciprocity or mutual respect are thus presupposed in actuating narrative. Narrative is one of two modes of thought in reflecting experience (Bruner, 1986). The logico-scientific mode deals in general causes and their establishment and tests for empirical truth. The means by which these two modes can be used to convince are different, one seeks to appeal to procedures for establishing formal proof, the other through verisimilitude, providing narrative stories of lifelikeness (Bruner, 1986), the former seeking to *explain*, the latter to provide a means of *interpretation* (Bruner, 1996). But both are ways of structuring experience.

Through the deployment of particular protagonists it becomes possible to envisage how alternative actions lead to different consequences, some liberatory, some oppressive; even liberatory actions might have adverse implications for other communities.

Consistent with this approach is the use of narrative as a resource which enables identification of socio-scientific issues and the opportunities to seed dialogue. As a tool narrative:

> *has the power to make us see the lives of the different ... with involvement and sympathetic understanding, with anger at our society's refusal of visibility. We come to see how circumstances shape the lives of those who share with us some general goals and prospects. (Nussbaum, 1997)*

PAULO FREIRE'S IDEAS

Freire first developed his political philosophy among rural peasant communities and the urban poor of Brazil, and later, in Chile and in African countries. The basis of his educational thought is anthropological and it is addressed to oppressed people for ontological, epistemological and ethical reasons. We cannot understand his proposal if we do not take into consideration the context of oppression in the Third World.

The most important contribution of Paulo Freire's books and of his practise were to make people believe that it is possible to change the capitalist exploitation framework. He designed a philosophy which considers knowledge as a product of humane practises that result in the transformation of the world by the consciousness of the students. This occurs when they can understand through learning how they are being exploited through capitalism. The education process needs to be carried out from the social and cultural context of the students in such a way that the teacher can generate discussion from the teaching content to comprehend power relations in society. Freire (1974) states: 'To be human is to engage in relationships with others and with the world' (p. 3). From this engagement students can understand the exploitation process.

As a consequence education must consider the world in which man and woman exist, what it means to understand the inequality of power and the life conditions around different social classes.

In this sense, his proposal was initially developed for the context of the political oppression in Brazilian society at the time. He supported the idea that education, in Brazilian society, characterized by oppression, needed to help people enter the historical process critically (Freire, 1972, 1974, 1976). To accomplish this basic task, a form of education that enabled people to reflect, by themselves, on their responsibility and on their role in the new cultural climate (Freire, 1974) was called for. This new cultural climate would be a process in which instead of oppressed people silently accepting, a determined mode of being from the dominant capitalist class, i.e. the oppressors, they became political activists. Since Brazilian society at that time had all the characteristics of a 'closed society' in an alienated cultural context, in which the political decisions were take only by the elite, it was necessary to create an educational process as a practise of freedom that was supported by the pedagogy of the oppressed and aimed at changing the context of alienation and oppression.

The basis of his ethical and political educational theory is the contradiction between the oppressors and the oppressed. One can exist only in the presence of the other. Therefore, the principle of the education for freedom is that the oppressed cannot be developed from the oppressor's values.

Freire adopted a dialectical approach toward understanding the world, establishing a relation between consciousness and the world. Consciousness, according to Freire (1972), is created from reality. Taking into consideration that the world is unfinished and knowledge is dialectical, Freire (1972) states that knowledge is constructed and it can transform the world. In others words, instead of the 'closed society' which does not give opportunities for oppressed people to participate in it, Freire (1972) supported the idea that the educational process for freedom could transform this situation.

The basic principle of his pedagogy is dialogue. Freire (1972) said that education for critical consciousness should be developed through a dialectical process, which involves dialogue among individuals. It is by way of dialogue that man and woman are humanized. Words are not a mere expression of thought; they are a transformation of praxis, which acts upon the world. 'It is in speaking their word that (people) transform the world in naming it, dialogue imposes itself as the way . . .' in which human beings achieve significance as members of a common humanity (Freire, 1972, p. 61).

Whereas in the domination process the subject conquers another person and transforms him into a 'thing', the dialogical process has a dialectic feature in that one does not annul the other, as it occurs in the 'banking' educational process explained below. According to Freire (1972) in the dialogical process, subjects meet in cooperation to transform the world.

> *The dialogical "I", however, knows that it is precisely the "thou" ("not-'I'"), which has called forth his own existence. He also knows that the "thou", which calls forth his own existence, in turn, constitutes an "I", which has in his "I" its "thou". The "I" and the "thou" thus become, in the dialectic of these relationships, two "thous" which become two "Is".* (Freire, 1972, p. 135)

Dialogue does not impose, does not manipulate, does not tame. It unveils reality. In cooperation, the dialogic process focuses on reality that, posed as a problem, challenges the persons. It is opposed to the education made by the oppressors, which Freire (1972) called 'banking' education:

> *Education thus becomes an act of depositing, in which the students are the depositories and the teacher is the depositor. Instead of communicating, the teacher issues communiqués and "makes deposits" which the students patiently receive, memorize and repeat. This is the 'banking' concept of education, in which the scope of action allowed to the students extends only as far as receiving, filing and storing the deposits. They do, it's true, they do have the opportunity to become collectors or cataloguers of the things they store (p. 45-46)*

Accordingly, anybody educates anybody: man and woman are educated by each other, mediated by the world (Freire, 1972). For him, educating for literacy is more than a mere act of teaching to read and write. Humanistic education goes beyond teaching contents without social meanings. It focuses on the human condition and on its transformation.

He designed a revolutionary adult literacy proposal, which was very successful around many Third World countries. This proposal is comprised of three stages: 1) an investigative and preparatory work in order to identify the learners' social situation and to prepare materials and agendas; 2) a discussion of the learners' existential situation by analysing generative words and a series of pictorial representations of their adult culture; and 3) a syllabic combination by using generative words, starting with the reading of the words and the construction of new ones, continuing, however, the literacy process integrated with an exploration of contexts from which generative words emerged (Freire, 1976). These stages can be summarised as: reading of the world, sharing the world with others, and constructing and reconstructing the world. To read the world, we need to start with their cultural needs, and the learners need to have an epistemological curiosity. For Freire, human interest comes before knowledge. To share the world, knowledge needs to be mediated by a dialogical process. In this stage, culture is analysed from the generative words and pictures. This is a stage in which students develop a codification and de-codification process of the world. In the last stage, the world is constructed and reconstructed. Students learn to read and write the new words and discuss the actions to engage in the transformation of the existential situation around the generative words. For instance, from the generative word favela (slum), the problems regarding housing, health, food, and education are debated with student groups.

In this educational process, students develop an awareness of their situation, which is a political agenda. Freire firmly believed that education could not be neutral; that learning never takes place in a vacuum (Freire, 1972, 1994). In fact, those who believe that the teacher has to be 'apolitical' are unintentionally and naively supporting the dominant ideology imposed by technological systems. They reinforce it when they do not discuss it with their students. In this respect, Freire postulates:

> *The very nature of the educational practice – its necessary directive nature, the objectives, the dreams that follow in the practice – do not allow education to be neutral as it is always political… The question before us is to know what type of politics it is, in favor of whom and what, and against what and for whom it is realized. (Freire, 1993, p. 22)*

In conclusion, the humanistic science educational in the Freire's view requires that the educator to have a commitment toward social change, taking into account larger global concerns, focusing on equity and social justice (Santos, 2009). These political agendas have been proposed for science education (e.g. Barton et al., 2003; Barton & Tobin, 2001, 2002; Elmesky & Tobin, 2005; Roth & Barton, 2004).

In this way, we can use Freire's ideas to construct a radical perspective towards scientific literacy for citizenship, introducing socio-scientific issues (SSI) in science lessons through 'interlocking narratives' as we discuss next section.

INTERLOCKING NARRATIVES

Using the idea of interlocking narratives, Levinson (2009) shows how chemical concepts such as the reduction of aluminium ions in the manufacture of aluminium, are interconnected with the spoliation of sites of natural beauty, opportunities for recycling, initiating social justice programmes for rubbish-pickers in Brazilian cities and threats to employment for workers in Jamaica (Figure 1).

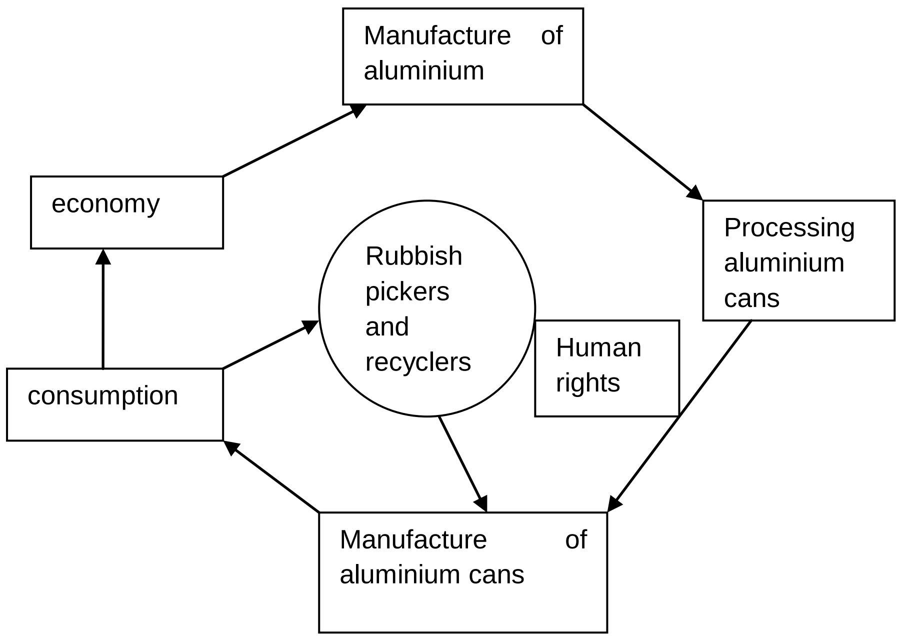

Figure 1: A cycle of linked events between the manufacture of aluminium, street-recyclers and their human and political rights.

Hence in figure 1, the manufacture of aluminium from bauxite involves a huge consumption of energy often provided by hydro-electric power stations which damage areas of natural beauty. The aluminium is processed for the manufacture of drink cans. However, Brazilian urban rubbish pickers, the *catadores de lixo*, recycle the cans. This has a number of effects which have transformed their lives. Recycling reduces the necessity for aluminium manufacture and the *catadores*, through unionising, have gained sufficient political power to transform their own lives and gain important human rights such as housing and schooling.

These stories then become teaching opportunities in identifying conditions of oppression and discussing resulting action. There are many different themes in science and technology with lend themselves to this kind of approach. For example, the role of tea-gatherers in East Africa or Palestinian farmers dependent on water in conflict situations, the technology underpinning a genetic test kit and its social implications, community action in rebutting the patenting of the Neem tree (Shiva, 2001).

Examples of narratives are also found in the textbook *Chemistry and Society* (Santos et al, 2005), developed for Secondary Schools by the *Chemistry and Society Teaching Project* in Brazil. In this textbook topics are driven through stories of justice and social equity from science and technology, for example the life condition of workers in landfill sites can be studied through an understanding of properties of matter and separation methods, and differential and inequitable access to foods around the world from the study of agriculture and chemistry.

The texts that incorporate narratives establish links with chemistry concepts and political issues to be discussed by students (Santos et al, 2006). The political issues are introduced from poems, pictures and questions about the technological conditions around the world. Activities to engage students in political action in communities are suggested in a special section of the textbook.

CONCLUSIONS AND IMPLICATIONS

From Freire's ideas scientific literacy has a radical perspective in transforming society towards justice and social equity. We suggest in this paper that the humanistic science education in this radical view can be carried in science education from socio-scientific issues, which could be introduced by teaching through interlocking narratives.

The use in science education of interlocking narratives interconnected with social issues could empower political discussions. However, implementation in the classroom is problematic. Teachers can lack confidence in raising these issues and managing discussions (Levinson & Turner, 2001, Levinson, 2001, Bryce & Gray, 2004) and schools themselves often operate under undemocratic conditions which stifle possibilities of action (Flutter & Rudduck, 2004). One possible approach is through directed teaching of political literacy (Ruitenberg, 2009) congruent with dialogic action which makes political options both explicit and realistic. Identifications of contradictions inherent in these interlocking narratives can become a focus of discussion in classrooms and among teachers, and even seemingly insignificant actions such as the implementation of fair-trade products in school demonstrate how dialogue can be transformed into action. Mapping discussions and associated actions through dialogic action anticipates future research initiatives.

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CONCEPTIONS OF ENVIRONMENT IN A CONTINUING EDUCATION COURSE FOR SCIENCE TEACHERS IN BRAZIL

Mauricio dos Santos Matos

University of Sao Paulo, Brazil

maumatos@ffclrp.usp.br

Myrna Coelho-Matos

University of Sao Paulo, Brazil

myrna@iacep.com.br

Paulo Barbosa

University of Sao Paulo, Brazil

paulobarbosa@usp.br

ABSTRACT

Studies focusing on environmental education and continuing education of science teachers play an important role in the science education area. This research analyzed conceptions of environment in a continuing education course for science teachers developed at the University of Sao Paulo, Brazil. The analysis of the material was made using a qualitative approach and content analysis methodology. The conceptions of environment were analyzed and characterized by the use of categories previously defined and selected from the literature. Although different conceptions were identified, the conception of environment as a resource prevailed, demonstrating a serious limitation of the course in the environmental education of the participating science teachers. As a result of the training process, a naive and limited view on environment by teachers was observed. The results point to the need to reformulate continuing education courses in order to favor a more critical environmental education.

Keywords: *environment, science teacher, continuing education.*

INTRODUCTION

Over the last decades, science education research has been preoccupied with the way science is associated with ethical, political and social aspects. In this context, studies focusing on environmental education and continuing education of science teachers play an important role in the science education area.

Kuhn (1980) and other researchers have shown the importance of in-service training for science teachers to keep abreast of changes in their field in subject matter, curriculum development and instructional techniques. Aleixandre & Gayoso (1996) present an approach that attempts to use environmental education as a thread in scientific methodology courses intended for teacher education. In Brazil, an overview on science teacher education has been recently published (Villani et al., 2009). It analyzes the most significant events that have been occurring in Brazil's educational, social and political areas over the last half century, in comparison with a set of relevant worldwide events.

A clear understanding of the concept of training and the analysis of conceptual frameworks related to professional teaching conditions are fundamental to understanding the training process in which teachers are involved. Based on the classification of paradigms of Zeichner (1983), conceptual guidelines of Feiman-Nemser (1990) and the classification of Pérez Gómez (1998), Garcia (1999) proposed five types of teacher education orientation: academic, technological, personalist, practical, and social reconstructionist.

In the academic orientation, continuing education is seen as a process of transmission of scientific knowledge and culture, by means of a specialist training. In the technological orientation, education is seen as an applied science and the teacher as a coach who dominates the applications of scientific knowledge produced by others and transformed into rules of action. The personalist orientation believes that each person develops their own strategies to become a teacher, occupying the main role in teacher training to achieve personal development training. The practical orientation is found in the organization and development of teaching practices, and it valorizes learning from experience. According to that perspective, practical experiences contribute to providing teachers with better training, because they combine observation, direct experience and interrelationships with more experienced colleagues. The social reconstructionist orientation is an ethical and social reflection, seeking the ability to analyze the social context. In this orientation, teacher training is directly related to processes of change, innovation, and curriculum development for teachers, who are considered as individuals committed to the principles of social justice and democracy.

The characterization of the environmental approach in a particular educational context is generally thought considering the analysis of environmental education (EE) expressed in the context analyzed. From this perspective, a lot of research has been developed, identifying different conceptions of EE and proposing different categories to illustrate the form of ownership and the meaning assigned to that expression. As a result, a significant number of categories associated with the concept of EE are generated, whereupon there is a diffusion of meanings attributed to that expression.

This tendency of researches to identify the perceptions and meanings of environment and EE is pointed by several studies available in the literature. Parallel to these studies, other researches have been carried out aiming to characterize different conceptions of environmental education and environment in order to understand the different forms of ownership of these issues.

Sauvé (2005) proposes seven ways of apprehending the environment: as nature, as a resource, as a problem, as a system, as a place to live, as the biosphere, and as a community project. These categories are based on the understanding that environmental education can be understood from our relationship with the environment. Considering the importance of environmental education in teacher training, this research focus on the identification and analysis of the conceptions of environment expressed in the materials produced in a continuing education course occurred at the University of Sao Paulo – Brazil, assuming the environment as a key concept to the consolidation of a process of continuing education committed to an effective environmental education. This research leads us to the understanding of different forms of ownership of environmental issues in these courses, often presented as a challenge for the construction of a critical, complex and reflective thinking (Jacobi, 2005), as needed for the construction of teacher identity (Pimenta, 1999).

METHODOLOGY

This research analyzed conceptions of environment of a continuing education course for science teachers developed in 2006 at the University of Sao Paulo, Brazil. Such conceptions were identified through documental analysis of all material related to the course, including the basic guidelines proposed by the Sao Paulo government, the formal pedagogical project produced by the University of Sao Paulo, and the teachers' productions.

The analysis of the documents was made using a qualitative approach and conceptual analyses based on content analysis methodology in accordance to Bardin (1997) and assuming that words mentioned more often are those that reflect the form of ownership of important concepts in the documents examined.

Two types of units of analysis were used: sampling units and context units. Specific parts of content were selected as sampling units, and the analysis revealed the frequency of the terms listed in the table 1, all of them directly associated with the idea of environment.

Table 1 – Terms directly associated with the idea of environment that were used in the research in order to characterize the conceptions of environment.

Terms directly associated with the idea of environment
Environment(s)
Natural environment
Environmental
Socio-environmental
Sustainable development
Sustainability
Sustainable society
Nature

The set of terms related to conceptions of environment was built based on the researcher-object interaction and on exploratory readings of all the material analyzed.

Regarding the context units, not only their frequencies were analyzed, but also the contexts in which they occur. Annotations, tables, diagrams, and other sorts of brief communication were all used as sampling units, being part of the first stage of data classification, which also included the type of information source, the topics and themes addressed, and the nature of the material collected. After all the material was read and the data organization was completed, some categories of analysis were created based on the fact that, according to Bardin (2000), such type of categories can classify the elements of a group by means of differentiation and then regrouping, taking into account previously defined criteria. The information was grouped considering the terms with regular frequency expressing conceptions of environment that were associated with the categories proposed by Sauvé (2005), which are listed in the table 2.

Table 2 – Categories of environment used for the classification of conceptions of environment expressed in the material analyzed.

Categories of conceptions of environment*
As nature
As a resource
As a problem
As a system
As a place to live
As the biosphere
As a community Project

* Proposed by Sauvé (2005).

As soon as an initial set was obtained, the categories were assessed regarding their range, diversity, and limit. The idea was to identify the main environmental education (EE) perspective present in the course based on the dimension of the ownership of conceptions of environment.

The course analyzed was organized for the “Web of Knowledge” Program, focusing on educational topics related to science teaching and deepening themes of Science, in order to promote instructional transpositions and/or recontextualizations of scientific knowledge to the school context.

From the conceptual and methodological approaches of subjects of natural sciences, the teachers created thematic projects (TP) as a joint proposal between teachers from the same school or between teachers from different areas in order to encourage interdisciplinary collective actions in school after the continuing education course. In these projects, the participating teachers had the opportunity to carry out the planning and preparation of schedules of courses and teaching sequences on the theme, taking an active role during the course. The group of teachers consisted of people in the age range of 30 to 55 years, the majority of them (71.4%) being women. Their teaching subjects included Mathematics, Physics, Chemistry, Biology, and Science. In this regard, it should be pointed out the considerable amount of Biology teachers (33.33%) and the fact that 80.95% of the teachers were assigned to teach subjects related to only one knowledge area.

RESULTS AND DISCUSSION

Conceptions of environment in the basic project of the Sao Paulo government

It was observed that the term environment appears in the basic project of the Sao Paulo government with the meaning of place, associated to the context of learning environment. Nature was another term identified as a possible environmental focus. However, it is only used to characterize an area that includes some scientific knowledge. In both cases, there is not an explicit ownership of the concept of environment, which demonstrates the absence of environmental education in the basic guidelines established by the Sao Paulo government for continuing education programs designed for science teachers.

The basic project proposes the use of new methodologies focused on innovative practices and use of instructional materials. The training of teachers is focused on the development of skills for the use of new technologies with the adoption of assessment practices as a monitoring tool of teaching, emphasizing the development of skills in a continuing education based on technological orientation, as defined by García (1999).

Conceptions of environment in the pedagogical project of the course proposed by the University of Sao Paulo

As in the basic project, the term environment appears in the pedagogical project of the course with the meaning of place, referring to school as a place of learning situations. It is established that the environmental approach should be treated as one of the themes to be developed, but no explicit conception of environment is provided.

The absence of an environmental perspective for continuing education can be explained by the need for coherence between the pedagogical project proposed by the university and the one proposed by the Sao Paulo government, resulting in a repetition of several parts of the basic project of the government. In this regard, the pedagogical project can be considered as being only a bureaucratic and formal document without a detailed description of its real pedagogical intentions.

Unlike the basic project of the government, the pedagogical project of the course shows a strong academic orientation, focusing on specific scholar contents related to natural sciences. A practical orientation in a reflective approach (Pérez Gómes, 1992; Schön, 2000) is also observed, showing the concern of reflecting on the practice itself, involving all teachers in reading activities and records of texts. It is important to note that in both documents the absence of an environmental perspective is due to the emphasis on a continuing education with technological, practical and academic orientation.

Conceptions of environment present in the materials used by teachers during the course

The frequency of terms related to environmental issues present in the materials used by teachers during the course is shown in Table 3. It is observed that the terms environment and nature appear with more frequency in most of the materials analysed. However, it was not possible to clearly identify conceptions of environment using the categories proposed by Sauvé. This result suggests that there is not a prescription of a conception of environment present in the materials used by teachers in the course.

Table 3 – Frequency of terms related to environmental issues present in the materials used by teachers in the course.

Materials used by teachers	**EN**	**SE**	**SD**	**S**	**SS**	**N**
M1	4	0	0	0	0	4
M2	0	0	0	0	0	0
M3	4	0	0	0	0	7
M4	0	0	0	0	0	1
M5	1	0	0	0	0	0
M6	0	0	0	0	0	3
M7	4	0	0	0	0	25
M8	19	8	0	0	0	1
M9	1	0	0	0	0	3
M10	0	0	0	0	0	0
M11	3	0	0	0	0	5
M12	32	0	0	0	0	15
M13	0	0	0	0	0	0

EN: Environment; SE: Socio-environmental; SD: Sustainable development; S: Sustainability; S: Sustainable society; N: Nature

Conceptions of environment in thematic projects produced by teachers

The frequency of terms related to environmental issues is presented in Table 4.

Table 4. Frequency of terms related to environmental issues present in thematic projects produced by teachers.

Thematic projects	EN	SE	SD	S	SS	N
TP1	2	0	0	0	0	0
TP2	1	0	0	0	0	0
TP3	6	0	0	0	0	0
TP4	0	0	0	0	0	0
TP5	6	0	0	0	0	1

EN: Environment; SE: Socio-environmental; SD: Sustainable development; S: Sustainability; S: Sustainable society; N: Nature

The term environment was the most cited among the six terms used in the analysis of frequency. Only the thematic project TP4 did not make use of a term explicitly associated with environment.

In TP1, teachers point out that

> *"The theme of global warming was chosen because of the drastic consequences that the planet will suffer in the future, as well as because it integrates related disciplines and can be linked to the social, political and environmental... This theme sends an alert to young people (students) about the problems that may arise".* (TP1)

In TP1, the contents of the curriculum components are seen as knowledge to be acquired to minimize or solve future problems, which is characteristic of a conception of environment as a problem to be solved. However, the analysis of the other thematic projects produced by the participating science teachers shows the predominance of the conception of environment as a resource (Table 5), illustrating a serious limitation of the course in the environmental education of science teachers.

Table 5. Conceptions of environment in thematic projects produced by science teachers.

Thematic project	As nature	As a resource	As a problem	As a system	As a place to live	As the biosphere	As a community project
1	-	-	X	-	-	-	-
2	-	X	-	-	-	-	-
3	-	X	-	-	-	-	-
4	-	X	-	-	-	-	-
5	-	X	-	-	-	-	-

X= symbol indicating the presence of the conception.

In relation to the conceptions of education, the TPs produced by the teachers favor a practical perspective within a reflective approach. However, in the pedagogical project there was no emphasis on a technological and academic orientation.

These results indicate a possible correlation between a conception of environment as a resource and a practical approach, pointing to the need to reformulate continuing education courses in order to favor a more critical environmental education.

The incorporation of environmental issues in the educational process should include, as a first step, the involvement of the teacher, who should be aware of the need for this issue and then prepared and equipped to meet this challenge. We agree with Carvalho (2001) when he points out that it would be imprudent to reduce certain arrangements. The institutions responsible for education, along with other social sectors, should provide different educational opportunities for in-service teachers in order to ensure their continuing education.

Considering the different dimensions in teacher education proposed by Carvalho (2001), we understand that the course analyzed should explore more the dimension related to ethical and esthetic values and other initiatives that favor a more effective political participation of citizens.

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HOW TO MAKE TECHNOLOGY INTERESTING TO PUPILS?

Ivan Dović

OŠ Brinje Grosuplje (Primary School Brinje Grosuplje) / primary school teacher

ivo.dovic@gmail.com

ABSTRACT

In this presentation I will talk about my idea of making technology interesting to pupils aged between 11 and 14. During the nine years of my professional practice I have developed a successful method, stimulating the interest in technical subjects on our school to a high level. During my lessons I encourage pupils to gain knowledge through their own experience; therefore I always organize work according to the project learning method. I make sure that projects are interesting and entertaining to pupils and I try to include the largest possible number of aims, determined by the national curriculum. Such working method has proved to be successful- in school year 2009/2010 approximately 20% of pupils applied for model making class as one of extra-curricular activities at our school and 25% of pupils in the Years 7, 8 and 9 decided to take elective technology subjects. I will present two projects realised during the lessons of Design and Technology in Year 7 and model making class.

Keywords: *project learning method, curriculum, aims, electric car, eco speed boat, plastic, composite materials, fibreglass, electric motor*

INTRODUCTION

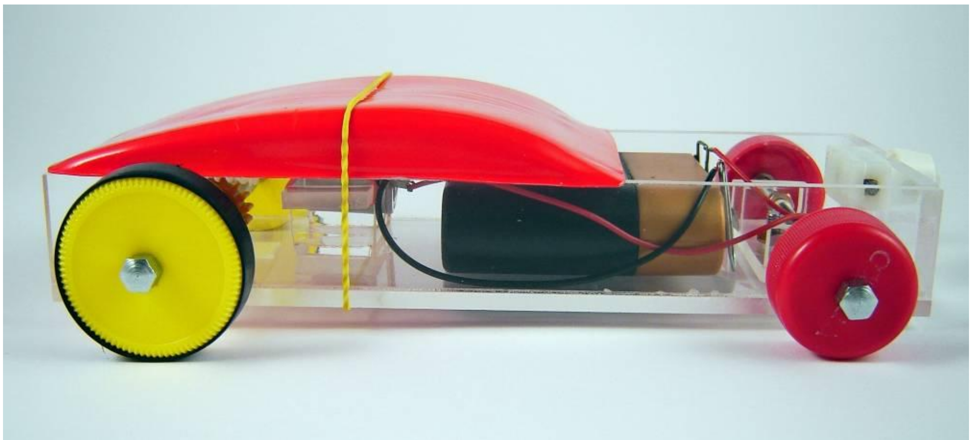
In recent years Slovenia has been facing a problem of an alarmingly small number of technically educated workers, who are able to create innovative and technologically perfected products with high added value. But on the other hand in the last primary education reform (introducing nine-year primary education system) the number of lessons intended for school subject Design and Technology was reduced by almost 50 percent. Such obvious paradox encouraged me to establish my own, and for some debatable, teaching concept. I no longer blindly follow the national curriculum in achieving every written aim. Such teaching practice allows only less active interaction patterns (whole-class teaching, power-point presentations, etc.) Apart from this the achieved aims are assessed with the National Assesment of Knowledge. This consequently encourages the above mentioned forms of interaction, which ensure a “successful” input of knowledge.

I believe the mission of a primary school teacher is not only to extend certain knowledge, which is sadly too often obsolete, but also to enable pupils to witness and actively engage themselves in numerous areas of design and technology. If a teacher succeeds and sparks the interest of pupils for technical subjects, he/she has to be able to encourage a pupil to seek further information and knowledge. A teacher should also trust a pupil will eventually master such knowledge and improve it.

Sadly, I have noticed that Slovenian teachers prefer to realize more traditional contents and try to evade demanding topics such as electronics and robotics. Teachers should be competent enough to create optimum conditions and enable pupils to learn about these topics through their own experience and not just theoretically. Pupils learn more effectively when they are successful at their work and it is a teacher's responsibility to plan activities which make this possible.

When I plan lessons I always keep in mind that pupils must gain knowledge through their own experience. At the end of every project pupils make their own products and I try to include the largest possible number of aims determined by the curriculum during the making. In the following paragraphs I will describe two projects- the first one was carried out during the lessons of Design and Technology in Year 7 and the second one during the model making class.

THE MAKING OF AN ELECTRIC CAR MADE OF PLASTIC MATERIALS



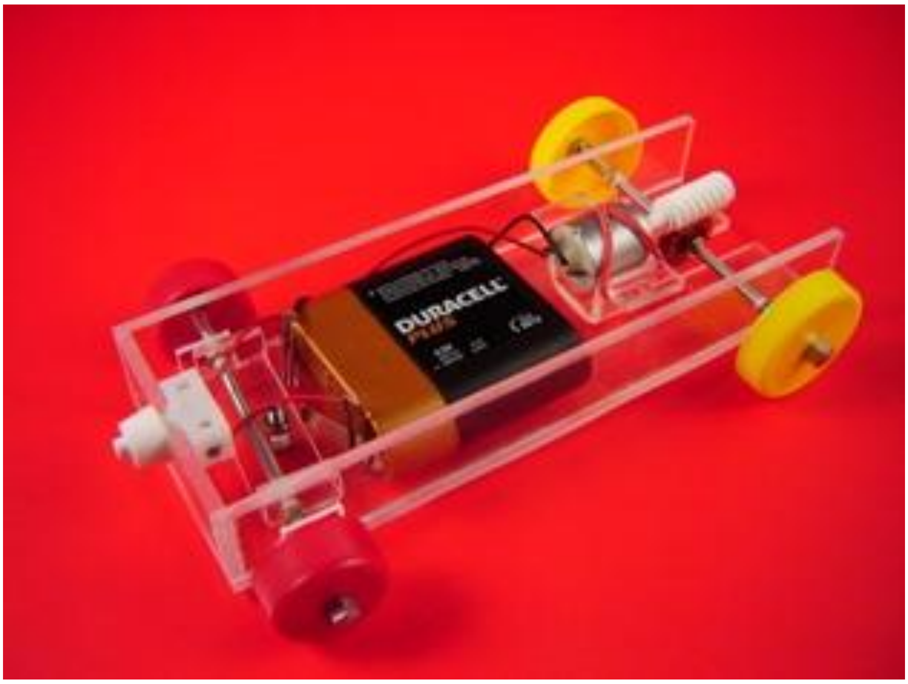
Picture 1.

During the lessons of Design and Technology in Year 7 pupils assemble an electric car made from plastic (Picture 1). The making of the car includes the most important curriculum goals and contents of Year 7: synthetic materials, electricity, motion transfer mechanisms, computer control, technical drawing and ecology.

The aims of the curriculum content Technical drawing are achieved in a phase of designing the car. Pupils draw plans of the car with a computer programme Cici-Cad and learn the basic rules of computer aided design.

Car body is made from two different synthetic materials. Acrylic glass is used for the car's understructure. During the making of the car pupils discover basic characteristics of acrylic glass (it softens when heated, its soft surface is sensitive to mechanical damage) and its basic manufacturing procedures - sawing, grinding and drilling. Apart from this they use a more demanding procedure- thermal transformation. The top of the car is made from polystyrene, another thermoplastic, which softens when heated. In order to make the top part pupils reshape polystyrene with a technique called deep drawing.

The car is powered by an electric motor. Pupils have to wire it up into a closed electric circle with a switch and a source of voltage. At this point pupils learn that the electric motor functions as a consumer and the battery as the power source. We also discuss other sources of electric energy and debate whether they are suitable for the car.



Picture 2.

In addition, pupils are presented with the possibility of changing motor's spinning direction with two switches and encouraged to think about a different use of switches in an electric circuit (logic gates).

In the next step pupils have to create a motion transfer from the motor to powered wheels with worm and spur gears. They discover that the motion transfer is possible only from the worm gear to the spur gear and that this gear pair changes the axis' direction of spinning and reduces the number of spins. Pupils also debate whether the number of spins could be changed in any other way.

The making of the car is also an excellent opportunity to think about the environmental problems, especially about the influence of synthetic materials on the environment. To contribute to a cleaner environment pupils reuse plastic bottle caps as wheels. Apart from this they also like to speculate about electric cars of the future.

The making of the car almost entirely fulfils the aims determined by the curriculum. Pupils find it interesting and they work enthusiastically through the whole process. Every June, during the longest break, pupils race their cars in our school's hall. The racers, as well as the spectators, find this event pleasant and interesting.

I sincerely believe that teachers should give careful consideration to the emotional component of teaching and learning when planning lessons.

The process of designing and making a product as well as learning new skills should be carried out in a relaxed and pleasant atmosphere. Thus pupils subconsciously perceive technology as something enjoyable and fun. These positive feelings will form their motivation pool and encourage further studies, research and work in the field of technology.

BUILDING A 3.5 METRE **LONG ELECTRIC SPEEDBOAT IN A MODEL MAKING CLASS**

Picture 3

In the second year of my teaching the pupils of a model making class expressed a wish to make a real sailing boat instead of usual model crafts. At first it was meant as a joke, but later we decided to face the challenge and in the same year built a 3 metre sailing boat (Picture 3). The project was a success in every possible aspect and from then on we have continued to undertake more complex projects.

In the following years we have built also a 2.5 metre long Space Shuttle and an electric car. Our most recent project has been developed for two years. It is a 3.5 metre long speedboat with an electric drive (Picture 3).

It was again the pupils who came up with the idea because they had grown tired of waiting for favourable winds to sail with a sailboat. In order to engage pupils at a maximum level a design competition was held at our school. Together with the members of the model making class we established that the traditional boat building methods are unsuitable. Therefore we searched for techniques manageable for pupils which would produce the results in a relatively short time.

Picture 4.

Picture 5.

We decided to make the speedboat out of 6 millimetre plywood and cover it with polyester resin and fibreglass (Picture 4, 5).

During the making the pupils learned many new woodworking skills (working with electric jigsaw and electric plane, bending wood). Furthermore, the speed boat was coated in polyester resin and fibreglass so the pupils also worked with composite materials used in boat and aircraft industry as well as in space technology. The pupils learned about mechanical engineering by planning and building in mechanical parts (they built in a motor, created motion transfer from motor to drive shaft, they built in a drive shaft, made it watertight and installed a propeller). One of the most demanding tasks was building in a steering mechanism, which has to withstand considerable forces. The making of the speedboat included also the knowledge of electronics. We had to wire the electric motor with an electric speed controller and a power source. Compared to this the wiring of a car radio and speaker was an easy task.

A detailed description of the speedboat's making is not necessary at this point. I believe I should emphasize the effects this project had on the pupils instead.

A remarkable success of this project is a consequence of the fact that it was the pupils who wanted to fulfil their dreams of building a speedboat. They spent their free time working hard and learning something new. The knowledge they gained is priceless because they acquired it through their own experience. A lot of mistakes were made but consequently the pupils showed a lot of creativity while searching for new, technologically improved solutions.

You are quite right if you think this project was time-consuming and technically demanding. A lot of skilled knowledge was required and I admit that at the beginning I had little idea what I was getting myself into. But my goal was to finish the speedboat together with the pupils and take a ride on a local pond. In the past two years I often had to search for solutions to technical problems. I believe that a teacher should continuously learn and search for new knowledge rather than to strive to know everything. The pupils learned that two heads are better than one and that one shouldn't run when facing a problem. One just has to work hard and search for solutions in all possible areas.

To sum up, we all learned a lot during this project. Being highly motivated for work we often stayed in the workshop after school and during holidays. We concluded our project with a successful public launch, considerable media coverage and we received a golden award at the national competition of young technicians.

You can learn more about the electric car, ECO speedboat and my other projects on http://www2.arnes.si/~idovic/

THE *CRAR3FS2* FRAMEWORK FOR DEVELOPING TEACHERS' *ICT* SKILLS FOR SCIENCE EDUCATION THROUGH CYBERHUNTS

André du Plessis

Nelson Mandela Metropolitan University, Port Elizabeth, South Africa

andre.duplessis@nmmu.ac.za

Paul Webb

Nelson Mandela Metropolitan University, Port Elizabeth, South Africa

paul.webb@nmmu.ac.za

ABSTRACT

This paper investigated the use of a cyberhunt approach on the promotion of the critical learning outcomes required of South African science teachers by the national curriculum. The focus of this paper is on how the teacher development process for Information and Communication Technology (ICT) integration by means of cyberhunts, should be managed. The case study was conducted within the interpretive paradigm and made use of qualitative and quantitative data gathering methods. The data generated suggested positive results regarding the perceptions of the participating teachers towards the cyberhunt strategy. The data suggest that the CRAR^{3}FS^2 model seems to be a successful framework to develop teachers for the cyberhunt Internet-based teaching and learning strategy. It is proposed that teacher-development facilitators should take note of the CRAR^{3}FS^2 framework when they plan and implement Internet-based teacher development sessions which teachers can implement as teaching and learning strategies within their classrooms.

Keywords: *CRAR^{3}FS^2 framework, Teacher development, ICT, e-Education, Cyberhunts, Internet, Science education*

INTRODUCTION

Learner performance in the annual South African grade 12 exit examinations has been generally and consistently poor for decades (Fleisch, 2008; Christie, Butler & Potterton, 2007; Taylor & Vinjevold, 1999), while the country attained last place in the Third International and Mathematics and Science Study in 1998, and in the Trends in Mathematics and Science Study in 2003 in both science and mathematics. These poor results have been attributed to many teachers' inability to stimulate attitudes of curiosity and critical thinking skills and their reliance on rote learning, memorisation and recall (Christie, Butler & Potterton, 2007; Taylor & Vinjevold, 1999). As such the training of teachers (both pre- and in-service) has been identified as a key aspect in implement the modern approaches envisioned in the latest South African national curriculum (Kallaway, 2007). However, there are a number of barriers to successful teacher development, which include teachers' lack of knowledge, skills and self-belief (Christie, Butler & Potterton, 2007).

The critical outcomes of the South African National Curriculum Statement (NCS) specify that learners should be able to (1) identify and solve problems by means of critical and creative thinking, (2) work together in teams, (3) manage themselves responsibly, (4) collect and analyse information, (5) communicate effectively, (6) use science and technology effectively, (7) see the world as set of related contexts, (8) employ effective learning strategies, (9) become responsible citizens, (10) be culturally and aesthetically sensitive, (11) explore education and career opportunities and (12) develop entrepreneurial abilities (Department of

Education, 2002). In the Science Learning Area, the curriculum attempts to address issues of developing scientifically literate citizens (Department of Education, 2002). The generative use of ICT via Cyberhunts is seen as one way of attaining these learning outcomes and to address the cognitive development of learners (Du Plessis & Webb, 2008). This paper, which forms part of a larger study on ICT in schools, reports on which aspects should be taken into consideration to develop teachers for successful ICT implementation of science created cyberhunts as an Internet-based teaching and learning strategy (Du Plessis, 2010).

CYBERHUNTS AND KNOWLEDGE AS DESIGN

A cyberhunt refers to an online activity where learners are using the Internet as a tool to find answers to pre-determined questions (Rechtfertig, 2002) based upon a certain theme or topic. These questions are usually on different cognitive levels, and teachers may use cyberhunts as an introduction to a theme in a pre-activity, as a review for an upcoming test or as another form of authentic assessment (Slayden, 2000). Cyberhunts can also be used as a knowledge generation tool when learners become cyberhunt designers (Du Plessis, 2010). Learners-as-designers of their own cyberhunts on a topic should be the ultimate goal in cyberhunt design for teaching and learning. This relates to the idea of knowledge as design (Perkins, 1986; Harel & Papert, 1990) where learners become designers or users of knowledge instead of passive consumers of knowledge, when they construct, compose, write by typing and investigate (Du Plessis, 2010).

The use of computer technology by learners to design artefacts in order to develop cognitive skills is not, in itself, a novel idea in education as illustrated by the research of Carver, Lehrer, Connell, & Erickson (1992); Lehrer, (1993), Lehrer, Erickson and Connell (1994) and Du Plessis (2004). However, learner created or learner designed cyberhunts is a novel idea, as learners not only become the designers, but they also compose questions on different cognitive levels about the topic(s) that they explore. Composing questions on different cognitive levels requires a significant preparation from the teacher's side as he/she has to introduce the learners to the different cognitive levels and to the different verbs which are associated with each level.

Research has shown that when learners design computer based artefacts by using the computer as a cognitive design tool (e.g. within a knowledge-as-design context), the major thinking skills that learners need to use as designers of these systems, include project management skills, research skills, organisation and representation skills, presentation skills and reflection skills (Lehrer et al., 1992; Lehrer, 1993; Lehrer et al., 1994; Liu, 2003, Du Plessis, 2004; Du Plessis, 2010). Each of these skills include various sub-skills, for example, research skills include reading, note taking, defining or creating keywords, validation of the quality of knowledge, search skills, and so on (Du Plessis, 2010).

Yore & Treagust (2006) argue that the focus of science curricula should be the development of learners' cognitive tools and their communication abilities in science. Hokanson and Hooper (2000) argue that when ICT is used in education, it should foster thinking. Hence, when one combines science and ICT in teaching and learning, the main emphasis should therefore be on enhancing cognitive abilities. We are of the opinion that teacher created cyberhunts and especially learner created cyberhunts, have the potential to enhance learners' cognitive and communication abilities in the science curricula when learners create science based cyberhunts. Our argument is based on the fact that when learners become the designers of cyberhunts and not mere users of pre-designed cyberhunts, it is possible for the 'learners-as-designers' to acquire Internet related skills, e.g. searching the Internet by making use of search engines, the identification and evaluation of the level and appropriateness of websites to be included for their cyberhunts and even enabling them to compose questions on different cognitive levels (Slayden, 2000; Rechtfertig, 2002). In addition, it is also important to note that the main focus of the learner-designed cyberhunts is on the design skills (Lehrer et al., 1992; Lehrer, 1993; Lehrer et al., 1994; Liu, 2003, Du Plessis, 2004).

The main difference between learner-created cyberhunts and other web based activities is the fact that in the learner-designed cyberhunt, the learners have to compose questions on different cognitive levels that their peers (or even other teachers) have to answer by exploring the provided hyperlinks. It is important to note that the composition of questions and memoranda by learners is not a key element in webquests and project-based learning web based activities. We are of the opinion that cyberhunts do have the possibility to generate thought as cyberhunts could become a learning tool for learners and even other teachers, as learners and teachers may utilise the learner-designed cyberhunts to explore a topic. Learners may therefore use the learner-designed cyberhunts to enrich their knowledge, to ameliorate understanding of a topic(s) with which they struggle and/or even to learn and discover at their own pace. Thus, cyberhunts could be used to move learners who struggle with certain aspects within the curriculum, through the Zone of Proximal Development (Du Plessis, 2010). It is therefore argued that the generation of thinking is precisely what could happen when learners answer the composed questions in a cyberhunt or when learners themselves compose questions when they design their own cyberhunts.

The dominant model of computer deployment and computer utilisation in South African schools is the computer room or laboratory where learners work individually and the main focus is computer literacy (Department of Education, 2002). ICT integration seems to be minimal (Department of Education, 2002). It is therefore imperative that other alternatives are explored that will change this situation (Department of Education, 2004). Cyberhunts is totally different from the dominant model, as computer literacy is not the main focus, but the generation of thinking is.

It is important to note that for learners to become designers, their teachers need the design skills required for cyberhunt construction in order that the teachers can empower their learners through a facilitation process to become designers also. This teacher development process would need careful planning, especially pertaining to composing questions on different cognitive levels, as the teacher would have to introduce the learners to the different cognitive levels and to the different verbs which are associated with each level (Du Plessis, 2010).

When learners compose their own questions for their cyberhunts on different cognitive levels about a topic that they explore, they are thus linking this to the identification of a question(s) as required for the development of scientific literacy (Webb, 2009). While the learners design their own cyberhunts either individually or in groups, they acquire new knowledge, they need to explain certain aspects, they have to determine whether the information is truthful and they can be afforded with reflection opportunities regarding their experiences during the design process by means of journal writing (Du Plessis, 2010).

TEACHER DEVELOPMENT

Staff development programs with respect to technology, should be (1) hands-on, (2) on-going, (3) providing staff with the technology equipment, (4) incentive driven, (5) should be reviewed regularly (Picciano, 2006) and should include reflection as a learning tool (Hoban, 2002). Lawless and Pellegrino (2007, p. 597) argue that professional development should have as its focus to assist teachers to change their pedagogies with a view to improve teaching and learning, hence they argue, the question professional developers have to ask is, “What do teachers do differently in their classrooms as a product of professional development?” Therefore, one should ask oneself when deciding on a specific teacher development model, whether this model will result in teachers changing their pedagogies.

We are of the opinion that learner-designed cyberhunts have the possibility to add to the pedagogic repertoire of teachers.

METHODOLOGY AND METHODS

The research formed part of a larger study that used quantitative and qualitative data gathering tools. The research project was conducted within the post-positivist paradigm (Niglas, 2001; Mertens, 2005) underpinned ontologically by a critical realist position (Sayer 2000; Benton & Craib, 2001) and epistemologically by a socio-cultural perspective (Vygotsky, 1978; Engeström & Miettinen; Roth & Lee, 2007). Qualitative and quantitative data gathering methods (mixed research) were used (Kelle & Erzberger, 2004; Johnson & Christensen, 2008) within an interpretative case study (Yin, 2003). Quantitative data gathering tools that had been used in the larger study; comprised of Likert scale questionnaires, a computer skills questionnaire, as well as certain quantitative sections within the semi-closed-open-ended questionnaires. The qualitative data gathering tools that had been used semi-closed-open-ended questionnaires, journal- reflection sheets, observation and interviews. The summary of the findings reported in this paper, is based on the qualitative findings.

THE INTERVENTION, ITS THEORETICAL BASIS AND ITS PHASES

Thirty-six teachers from six poorly resourced (both human and material) schools (four primary schools and two high schools) formed the convenience sample used in this study, as each of these six schools received 20 computers for free from the Dell Foundation. The project ran from March 2008 to the end of September 2008 with an average attendance of 27 participants per session.

This intervention that took place was informed by a community of practice framework embedded by cognitive apprenticeship (Brown, Collins & Duguid, 1989). It is acknowledged that teachers' prior beliefs and knowledge related to classroom practice influence their interpretation of new pedagogical ideas (Putman & Borko, 1997) and new practices. However, teachers also learn a great deal from their social interaction(s) in discourse communities when they share experiences from the classroom contexts in which they experiment with new or alternative practices (Putman & Borko, 1997). During the teacher development process pertaining to cyberhunts, participants received regular opportunities for reflection through the completion of journal sheets at the beginning and end of the various cyberhunt teacher development sessions. This is in line with Hoban (2002) and Turbill (2002) who state that reflection and communities of practice are two important keys to assist with teacher development.

As a result of the value of social interaction as a learning tool through language, the knowledge creation model of Nonaka and Takeuchi (1995) was seen as a useful model for learning. Nonaka and Takeuchi (1995) identified two kinds of knowledge that play an important role in knowledge creation, namely tacit and explicit knowledge. The four modes of knowledge creation that are represented by Nonaka (1994) and Nonaka and Takeuchi (1995) are the sharing of ideas (socialisation), combining knowledge to test ideas (combination), emergence of new ideas (externalisation) and developing new ideas and learning by doing (internalisation).

In the first phase, the participants explored the Internet in a guided manner by providing them with web addresses type into Internet Explorer's address bar and then to explore these sites. Participants were also introduced to pre-designed cyberhunts in order that they could get a feel of cyberhunts. The Internet search engine, Google, was also introduced as well as Boolean searching. Participants were also introduced to the taxonomy of Bloom.

The second phase consisted of five stages. During the design copy stage, the project leader modelled the cyberhunt design process and the participants followed the instructions, drawing from tacit knowledge (Nonaka, 1995) and by articulating tacit knowledge, the tacit knowledge is converted to explicit knowledge. Being active participants afforded opportunities to learn from the modelling process and to improve self-efficacy through personal mastery, vicarious experience and verbal persuasion (Bandura, 1997). Two tool stages followed which empowered the participants with Word and PowerPoint in order to prepare them for the design of their group cyberhunts. In the design as a group stage, participants could share their tacit knowledge with one another through articulation by means of discussion and peer assistance while they design collaboratively. As a result the tacit knowledge becomes explicit and participants have an opportunity to try to link the new knowledge to their existing knowledge structure.

The presentation stage was the final stage during which participants received an opportunity to showcase their finished cyberhunt products and to obtain feedback from their peers. The assessment phase was the final phase during which participants were formally assessed.

SUMMARY OF THE FINDINGS

The participants highlighted the importance of the role of the facilitator during teacher development projects and placed a high priority on that person’s people skills and competence. Furthermore, it was noted that clear explanations, approachableness and constant feedback were highly valued. This is in line with Havelock and Zlotolow (1995) and George and Camarata (1996) who argue that building relationships and trust, as well as the containment of anxiety, are vital for teacher development.

In addition, participants indicated that they would highly value that the project facilitator visit them at school to assist them with classroom implementation. This was indeed a very positive stance, as teachers are the champions of change and classroom support could probably assist them to experiment with alternative approaches (Fullan & Smith, 1999; Mouza, 2005), for example by using the cyberhunt strategy.

Participants also highlighted the importance of a paper based guide and notes during training as this gave them some form of security. This seems to concur with Leach and Moon (2000) and (Hodgkinson-Williams, 2005) who highlight the importance of clear guidelines for implementation. Participants also said that they had experienced the training as totally different from any other training they had been involved with before. Data analysis suggests that the positive attitude, patience and good listening skills were valued by the teachers. They also highlighted the fact that the atmosphere was relaxed and that this was appreciated, which is in agreement with George and Camarata (1996) who emphasise the importance to contain anxiety when technology is introduced to people.

The teachers also explained that the training was different, because it was ongoing, not like the normal one day sessions. This emphasis of the importance of training that is spread over some time concurs with Royer’s (2002) thoughts. Overall, the majority of the participants stated that the pace of training was important. An aspect that made the use of capable peer facilitators very different and attractive, was the fact that the peer-facilitators could assist their fellow peers in their home language, isiXhosa. This enabled them to often render greater assistance to their peers than could be done in English. Consideration of the language ability of participants during teacher training is thus very important, as this could influence the successfulness of the training. In sum, the following aspects are vital for teacher development, namely (1) establishing a relaxed atmosphere, (2) containing anxiety, (3) the pacing of the training by taking the progress of the participants into consideration, as well as their individual needs, (4) using peer-facilitators, (5) modelling/coaching and mentor when appropriate and when required, (6) Be patient, approachable, and listen to the their learners’ needs, motivate them constantly, assist them and compromise when necessary (people skills), (7) Ensuring that the training is ongoing and progress feedback should be provided on a regular basis, (8) Ensuring that the training is hands-on, practical and explanations are clear, (9) encouraging the use of the participants' home language to explain to one another, (10) providing ongoing support keeping the school context in mind, (11) developing competence, and (12) providing opportunities for personal goal setting, reflection and the sharing of experiences.

The data generated via the teacher development process that was implemented in this study; which is underpinned by the collaborative, motivational, knowledge generative and situated cognition approach corroborated by cognitive apprenticeship principles; suggests that the intervention was effective. These data also informed the design of the framework discussed below for teacher development of this nature.

A PROPOSED FRAMEWORK FOR TEACHER DEVELOPMENT

This data suggest that the following aspects encompassed by the acronym $CRAR^3FS^2$, as indicated in Figure 1, can enhance teacher development and classroom implementation of this type of Internet-based teaching and learning strategy. The $CRAR^3FS^2$ acronym represents the verbs or actions that the participating teachers highly valued during implementation and what they have indicated as being important. The verbs or actions of the $C\ R\ A\ R^3\ F\ S^2$ framework are (1) Care, (2) Relate, (3) Assess, (4) Reflect, (5) Read, (6) Re-Plan (7) Feedback, (8) Share and (9) Support. The diagram also provides an overview of the proposed process for teacher development aimed at empowering them to use cyberhunts as a means to introduce the Internet to teachers. The same elements that were valued by the teacher participants during the teacher development training process should also form part of the implementation process of ICT related learning in their classrooms. Within the $CRAR^3FS^2$ framework, reflection through journal writing or by means of the completion of reflection sheets plays a vital role.

Care refers to establishing a learning context in which learners can experience and see that they are cared for and believe that the will be able to succeed with the new approach. Relate refers to building a relationship between the facilitator and the learners. Assess implies that the teachers should assess and identify the positive and negative aspects that have occurred during implementation.

Reflection refers to the completion of reflective journals consisting of several questions to which participants can reflect upon. The rationale behind the reflective journals is that they are a tool that enables both the designer and the teacher to obtain a snapshot of his/her progress for future planning. Hence, journal writing is strongly advocated as a tool to assist both the teacher and the learners in their planning, to determine their progress and to identify areas in which assistance is required.

Read refers to the teacher who has to read what the learners have written in their journals with a view to identifying aspects that would need attention the next time they continue with their cyberhunts. Re-plan and read is interlinked, as the teacher reads the journals to plan or re-plan for the next session in such a way that he/she addresses the issues at hand. It is also important to note that learners could also read one another's personal reflections in their journals, in order to assist them to understand that they are not the only ones who struggle with certain cyberhunt design aspects. Alternatively, the journals sheets could become an identifier of the 'capable peers' in their class whom they might approach when they need assistance.

Feedback is another important element, as constructive feedback during the lesson, at the end of the lesson, after personal observation, or feedback given after scrutinising the participants' (learners') journals, should assist the teacher to provide adequate feedback and help with preparation and planning for the next session. Share refers to the teacher creating opportunities for the learners to share their experiences of the learning process with their peers either in their groups or with the whole class in order to articulate their tacit knowledge, experiences, successes and needs. Lastly, support refers to both the project facilitator's and participants' role of rendering on-going support when the school based implementation process commences.

Support implies support that is on-going. This implies support from the project facilitator (or from the teacher when the teacher is involved with his/her learners) and from fellow expert participants (the peer-facilitators or from fellow learners within the school context) during classroom implementation. Thus, just as the project facilitator supported the participants during the training process, the participating teacher supports his/her learners in the classroom and the peers support one another too in a similar manner.

Support also implies classroom visits by either the project facilitator and/or other capable peers in order to render assistance and/or to discuss the successes, the areas where assistance is required and to plan how to address the identified issues at hand. The support aspect goes beyond classroom visits, as it also requires the establishment of an internal school based support group which will have to meet regularly to establish caring support. Furthermore, support implies that the principal and the senior management team (SMT) create the necessary learning space for the participants from their school, and support them on emotional, motivational and resource levels.

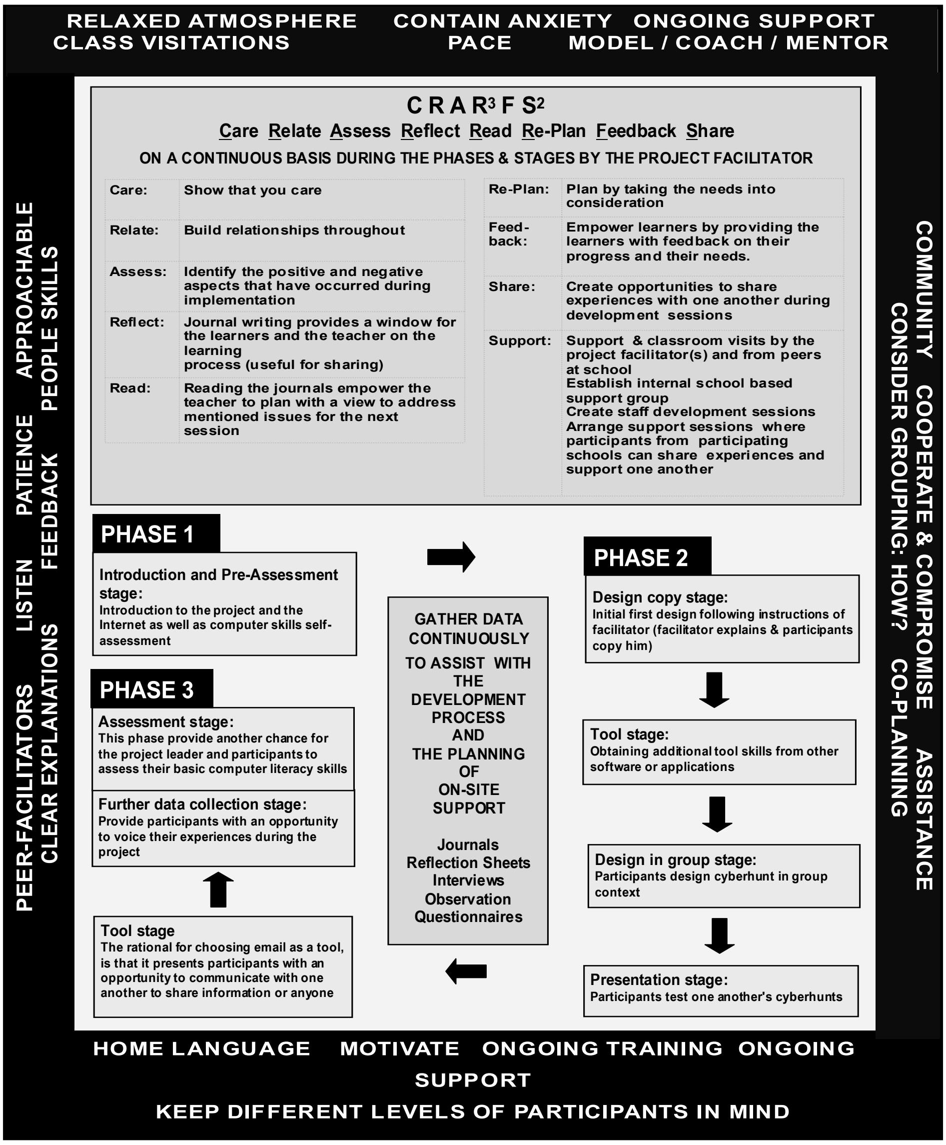


Figure 1: **Proposed phases and stages for teacher training and development related to cyberhunts**

In addition, support requires the institution of staff development sessions in order that the participants, who have received training, can share with other staff members who did not attend the training sessions what they had learned. Equally important, the staff development sessions can then also serve as training sessions for other staff members who want to be trained. Support also implies that the project facilitator and the participants decide upon specific times when all the participants from the different schools can meet in order for the participants to share their school-based experiences with participants from other schools.

The support session for teacher development thus become forums and during these sessions a platform is created to identify the areas in need for further training. These platforms enable the project facilitator to plan for future on-going support training sessions, as the facilitator plans by taking the identified need of the participants into consideration. The project facilitator can then decide whether the future training sessions will be planned by either the project facilitator alone, with the assistance and input of expert participants or by the expert participants on their own. Without the necessary ongoing support, it is highly likely that the implementation process at schools and the staff development at the participating schools could grind to a halt.

It is important that the facilitator (or the teacher who implements the ICT related activity at school) should also take note of the following aspects and responsibilities, during the teacher development process. These aspects and responsibilities forms part of the CRAR^{3}FS^2 framework and have to be planned for and kept in mind for the teacher development process to be successful, namely: (1) Establish a relaxed atmosphere, (2) Contain anxiety, (3) Pace the training by taking the progress of the participants into consideration, as well as their individual needs, (4) Use peer-facilitators, (5) Model/coach and mentor when appropriate and when required, (6) Be patient, approachable, and listen to the their learners' needs, motivate them constantly, assist them and compromise when necessary (people skills), (7) Ensure that the training is on-going and progress feedback should be provided on a regular basis, (8) Ensure that the training is hands-on, practical and explanations are clear, (9) Encourage the use of the participants' home language to explain to one another, (10) Provide on-going support keeping the school context in mind, (11) Develop competence, and (12) Provide opportunities for personal goal setting, reflection and the sharing of experiences. All the elements of the CRAR^{3}FS^2 model should be addressed at any point in time within the teacher development-training process. However, the care, relate and support components should receive attention from the start and should be on-going, as these components contribute to the creation of a positive learning context from the start.

CONCLUSION

The purpose of this paper was to present a framework for teacher preparation and teacher development regarding science education by means of cyberhunts as an Internet strategy for teaching and learning. It is proposed that the CRAR^{3}FS^2 framework for teacher development and classroom implementation can assist teachers embrace ICT implementation and integration. It is hoped that this paper, coupled with further research, might provide a starting point in unravelling a range of complex questions that might assist learners and their teachers to perceive school, especially science education, as being different to what they usually experience. We suggest that in this way ICT implementation in schools could become a tipping point by helping teachers transform their practice through seeing the fruitfulness of the approach and the possibilities that exist. However, the literature and the findings in this study suggest that on-going support is the key in this quest. Although cyberhunts were used as the vehicle for teacher preparation in this case, we do not mean to give the impression that cyberhunts are the only, or the best way, of assisting teachers to embrace ICT implementation and integration. Our experience during this research project does however indicate that the CRAF^{3}FS^2 teacher development framework has been successful to provide teachers with Internet and ICT skills. The framework generated from the data and from the teacher development processes that had been followed, reflects the aspects being viewed as important through the eyes of the participating teachers and teachers should have a voice during the teacher development process.

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SOCIAL AND ETHICAL ISSUES IN SCIENCE AT AGE 11 – 14: CREATING COMMUNITIES OF SCIENTIFIC ENQUIRY

Lynda Dunlop	Linda Clarke	Valerie McKelvey-Martin
University of Ulster	University of Ulster	University of Ulster
l.dunlop1@ulster.ac.uk	lm.clarke@ulster.ac.uk	v.mckelvey@ulster.ac.uk

ABSTRACT

Social and ethical issues in science that raise questions for individuals and society include stem cell research, drug development and exploration of the universe. Forward Thinking, Northern Ireland uses the development of communities of enquiry to promote discussion of these and other social and ethical issues in science with students aged 11 – 14. A questionnaire was used to evaluate this approach in 14 groups of key stage 3 students in 12 post-primary schools involving 301 students. Students reported that they found the project interesting and enjoyable and useful to help them learn science and to think about how they could improve. The majority of students reported that they continued their discussions after class. Teacher participants reported that the project helped them deliver the curriculum and that it supported development of their students' scientific knowledge, thinking skills and social skills. This approach shows potential for extended use in secondary science as a way of engaging students, dealing with social and ethical issues in science, identifying students' misconceptions and also for promoting thinking skills and improving scientific knowledge and understanding.

Keywords: *community of enquiry, philosophy for children, enquiry, discussion, science, ethics*

INTRODUCTION

Teaching about Social and Ethical Issues in Science

Ethical awareness is taking an increasing role in school science education. The Northern Ireland Key Stage 3 curriculum for students aged 11 – 14 (in the first 3 years of post-primary education) has recently been revised and now includes Ethical Awareness as a Key Element (CCEA, 2010). There are other reasons besides the curriculum for dealing with such issues in the science classroom: Reiss (1999, 2008) argues that science takes place in a social context and therefore ethics and science are inevitably connected, and that teaching ethics within science can help sensitize students to ethical issues, make them think of things they had previously been unaware of, help them improve their knowledge of ethics and also their ethical judgement, and that it may also help them become better people. Other advantages of dealing with ethical issues in a science class are that it may help students consolidate their understanding of a scientific topic, to improve their general thinking skills (e.g. by looking for reasons, counterarguments and examples) and that they might enjoy such classes and thereby become more engaged with science. However, teaching about ethics in science remains contested: some have argued that students' ability to philosophize about science (including ethically) will not be achieved to a great extent given the average intellectual ability of a high school student, the skills of the science teacher to teach science ethics and lack of time required to teach about ethical issues related to science (see Davson-Galle, 2008 and Reiss, 1999). The approach discussed in this paper does not involve explicitly teaching *about* ethics, but rather providing a forum in which students can critically evaluate different points of view on a question or issue (which may be social or ethical in nature) and attempt to reach a (provisional) resolution.

The Forward Thinking Project

Forward Thinking Northern Ireland is a teaching project for 11 – 14 year old students and their teachers that aims to encourage young people to engage with thinking about science and its ethical and social implications using the community of enquiry (also known as Philosophy for Children) methodology developed by Matthew Lipman (Lipman, 2003) and advocated in the UK by the Society for Advancing Philosophical Enquiry and Reflection in Education (Sapere). In doing so, it aims to address poor attitudes towards science in the region: attitudes towards science amongst students in Northern Ireland have been identified as poor compared to those in other countries, particularly in terms of their enjoyment of science and confidence in their general learning abilities (Bradshaw et al, 2007). This disengagement has resulted in declining interest in and uptake of STEM (science, technology, engineering and mathematics) subjects (Department of Education and Department for Employment and Learning, 2009). The community of enquiry approach has been successful for promoting learning, reasoning and self-esteem in other subjects (e.g. Trickey and Topping, 2004, Thwaites, 2005, Sprod, 1999). The Forward Thinking project applies this technique to a purely scientific (including socioscientific and ethics of science) context.

A community of enquiry is a group that is focused on solving the same problem or answering a common question through reasoning together collaboratively through dialogue. It involves teaching the process of thinking rather than what to think. The central idea is to provide a group learning environment in which students cooperate to test, share and improve on their thinking together (Splitter and Sharp, 1995). It is achieved by providing stimulus material (e.g. a news article, film clip, radio interview) and asking students to generate and organise questions based on this material. Students then discuss a selected question until it is resolved or until the students identify another question that must be answered. The role of teacher in the Forward Thinking project is to facilitate the discussion between students rather than participate in the enquiry, e.g. to ask procedural questions rather than provide answers for the students. The facilitator provides the space for discussion, focuses the dialogue and encourages deep consideration of the topic by modeling and the use of procedural questions (Gardner, 1996), rather than substantially inputting to the discussion. The facilitator for example may ask for clarification of key concepts, for reasons when stating an opinion, for examples and counterexamples. All participation in the discussion is voluntary. At the end of an enquiry, students then evaluate the process and the content of their discussion and decide where they want to go next. The community of enquiry approach offers students the opportunity to decide what they think is important to discuss based on the stimulus provided by the teacher. This approach gives students the freedom to opportunity to explore their own questions, and therefore direct their own learning.

Communties of Enquiry in Science

The topics included in the Forward Thinking project are designed specifically to provoke questions about controversial issues in science, particularly social and ethical issues. Themes include stem cell research, human and animal cloning, drug use in sport, pharmacogenomics, the search for exo-solar planets and the Big Bang. A typical session begins with an introduction to or refresher of the science involved in the topic under exploration followed by a stimulus which aims to introduce some of the issues associated with the topic, e.g. a short play about EPO use in sport, a music video or a genetic engineering photo album. The students then reflect individually and collectively on the stimulus and generate questions that they would like to explore. Some of the questions selected by students in the Forward Thinking project are shown in Table 1. Whilst the student-centred nature of question generation and selection means that specific content cannot be guaranteed to be covered during a session, the construction of a community of enquiry in science enables students to use their scientific knowledge in discussion and allow teachers to identify misconceptions and missing ideas that need to be taught in due course, as well as to ensure students use scientific vocabulary accurately.

Table 1: Topics and questions explored during the Forward Thinking project

Topic	Questions generated and selected by students aged 11 – 14
Cloning	Could cloning be used to bring back extinct or endangered species, or are they meant to die off? Why is human cloning illegal? Is it right to clone animals when they can't say yes or no? Should we clone? How would cloned embryos be inserted into the woman?
Intensive Farming	Do animals deserve to be treated like this? Why are bananas yellow? Should we mess with the genes of plants? Should animals be killed for us to eat them? Are we being cruel to animals and livestock? Should we let bananas die out?
Search for exo-solar planets	Should we explore other planets? Could humans adapt to an exo-solar planet? Why would we want to search for other life forms and make ourselves inferior or superior? If scientists find life besides Earth, what will happen to religion? How do we know that we are not the 'aliens'? Is it selfish to go to other planets, if we find them?
Stem Cell Research	Should the government fund stem cell research? Is using embryos in stem cell research the same as having an abortion? Should it even be considered as an enhancement when sick people are really in need of it? Is it better to do stem cell research than test on animals?

As the questions show, it is not the case that social and ethical questions are always selected as most interesting for the community to explore. Other types of questions, including technical questions (e.g. on embryo implantation) arise, and these can present opportunities for students to hypothesize and submit their own scientific ideas to scrutiny of the group.

During the enquiry, students are encouraged to address each other, and refer to ideas that other students have introduced to the discussion. This can be managed using different methods of organizing turn-taking. In the example in figure 1, a small cuddly toy version of penicillin is passed between students discussing issues relating to antibiotic resistance.

METHOD

Preparation of stimulus material

This research uses material created exclusively for stimulating enquiries based on social and ethical issues in science. The resources include short stories, role plays, videos, cartoons and interactive presentations. Figure 1 shows the outline of a typical enquiry session, and further resources are available on the website www.ulster.ac.uk/scienceinsociety/forwardthinking. Each resource includes ideas for introducing or revising the relevant science (e.g. modelling genetic engineering using DNA made from sweets or keyword games), a stimulus that highlights a particular issue (e.g. a cartoon or photo involving genetically modified organisms, e.g. the rhesus monkey used as a model for Huntington's Disease), an activity to help students generate and select questions, such as different voting techniques that can be used, and an evaluation activity where students are encouraged to reflect on the enquiry.

Participants

The Forward Thinking project has involved 301 students in 12 post-primary schools across Northern Ireland, of which 37% attend a selective school and 64% a non-selective school. 28% of respondents attend an integrated school. 52% attend a mixed school, 23% girls' school and 25% boys' school. The project was delivered in 6 – 8 hours of normal curriculum time through subjects including Science, Learning for Life and Work.

Figure 1 (a): Example of enquiry outline used in the Forward Thinking Project

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This resource is part of the Forward Thinking project. For more information visit:

www.ulster.ac.uk/scienceinsociety/

ANTIBIOTIC RESISTANCE

ANTIBIOTICS ARE USED TO TREAT MANY BACTERIAL infections. However, abuse of these antibiotics has led to several strains of bacteria becoming resistant to antibiotics. This means that the medicines are no longer effective against these bacteria or "superbugs."

OBJECTIVES

To understand how antibiotics are used correctly;

To explore the issues surrounding antibiotic resistance.

STARTER

Antibiotic use quiz (see page 2). To answer yes, students make a Y with their bodies by raising their arms in the air (as in YMCA), to answer no, they make a cross with their arms, and to answer don't know, they shrug their shoulders. Go through correct answers as you play. Recent NHS campaigns include the following advice on antibiotic use: take antibiotics only when prescribed, finish your course of antibiotics, don't take alcohol when using antibiotics and do not use anyone else's antibiotics. The evolution model can be used to help explain the development of antibiotic resistance.

STIMULUS

Split the class into pairs and give each pair the short paragraph on antibiotics with pictures on p2. Ask each pair to rewrite the paragraph, keeping the meaning of the paragraph the same, but without using any of the same words. Select a few pairs to share their "translations" with the class. Discuss similarities, differences and difficulties they had doing the task. Newspaper stories and/or headlines can also be used to stimulate discussion.

GENERATING QUESTIONS

Give students a couple of minutes silent thinking time to create an individual question based on the stimulus. Split class into groups of 3 and ask each 3 to share their questions and to select one they would like to discuss. This should be written on A4 paper. Read the questions and place them around the room. Ask students to vote by standing next to the question they would most like to discuss. Remove the least popular question and ask anyone who is standing there to transfer their vote by moving. Repeat until only 2 questions remain and start with the most popular question.

REFLECTING ON THE ENQUIRY

"Evaluating with emoticons" activity - see page 3.

NEXT STEPS

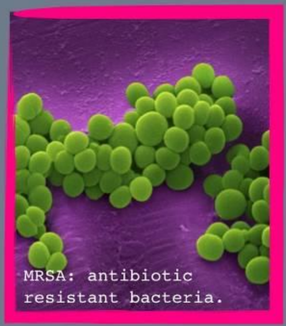
Students could design a survey to investigate understanding of antibiotic resistance and antibiotic use in their school.

Penicillin was the first antibiotic to be mass produced (in 1943). Although it does not kill bacteria, it stops them from reproducing by preventing bacteria from making a cell wall. Cuddly toy penicillin, MRSA and other bacteria are available from www.giantmicrobes.com/uk

Images © Wellcome Trust (www.wellcome.ac.uk) and NHS [1] www.ulster.ac.uk/scienceinsociety/

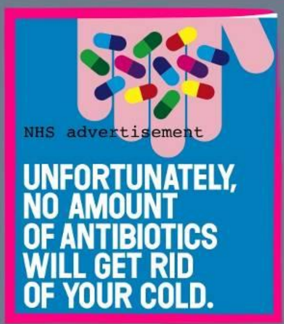
Figure 1(b): Starter and stimulus material for a session on antibiotic resistance

ANTIBIOTIC RESISTANCE



MRSA: antibiotic resistant bacteria.

Penicillium: a common antibiotic.



Antibiotics are medicines used to treat bacterial infections. They don't work viral infections (e.g. most colds and coughs). When antibiotics are used incorrectly, e.g. by not completing the course or by using someone else's antibiotics, it gives bacteria the chance to mutate and become resistant to the antibiotic - this means the antibiotics stop working. Antibiotic resistant bacteria can cause serious illnesses and be spread from person to person.

EVOLUTION MODEL

Bacteria divide many times a day, and some bacterial cells develop a mutation (change to a gene). Some of these mutations may offer resistance to antibiotics. This means that these bacteria are not destroyed by antibiotics: they go on to survive and reproduce. Proportionately more bacteria with the mutation will survive, leading to some strains of bacteria becoming resistant to antibiotics.

Ask for six volunteers to be "reproducing bacteria" and three volunteers to be "antibiotics". The rest of the class observe. The six "reproducing bacteria" will cut "bacteria" from paper using the template below. During a minute of cutting, talk about the bacteria population growing through asexual reproduction, and the limitations of asexual reproduction or cloning for diversity of the bacteria. After 1 minute cutting, introduce mutations, explaining their origin, e.g. from UV radiation, nuclear radiation and chemicals. Model this by giving one "reproducing bacteria" red paper to cut from, asking one to make the shape without scissors and by cutting part of the template. Allow a further minute of reproduction then give the instruction to the antibiotics: destroy any bacteria that are cut from white paper in the shape of the template. Label the remaining bacteria "antibiotic resistant". Discuss what will happen to the population of the different strains of bacteria as reproduction continues.

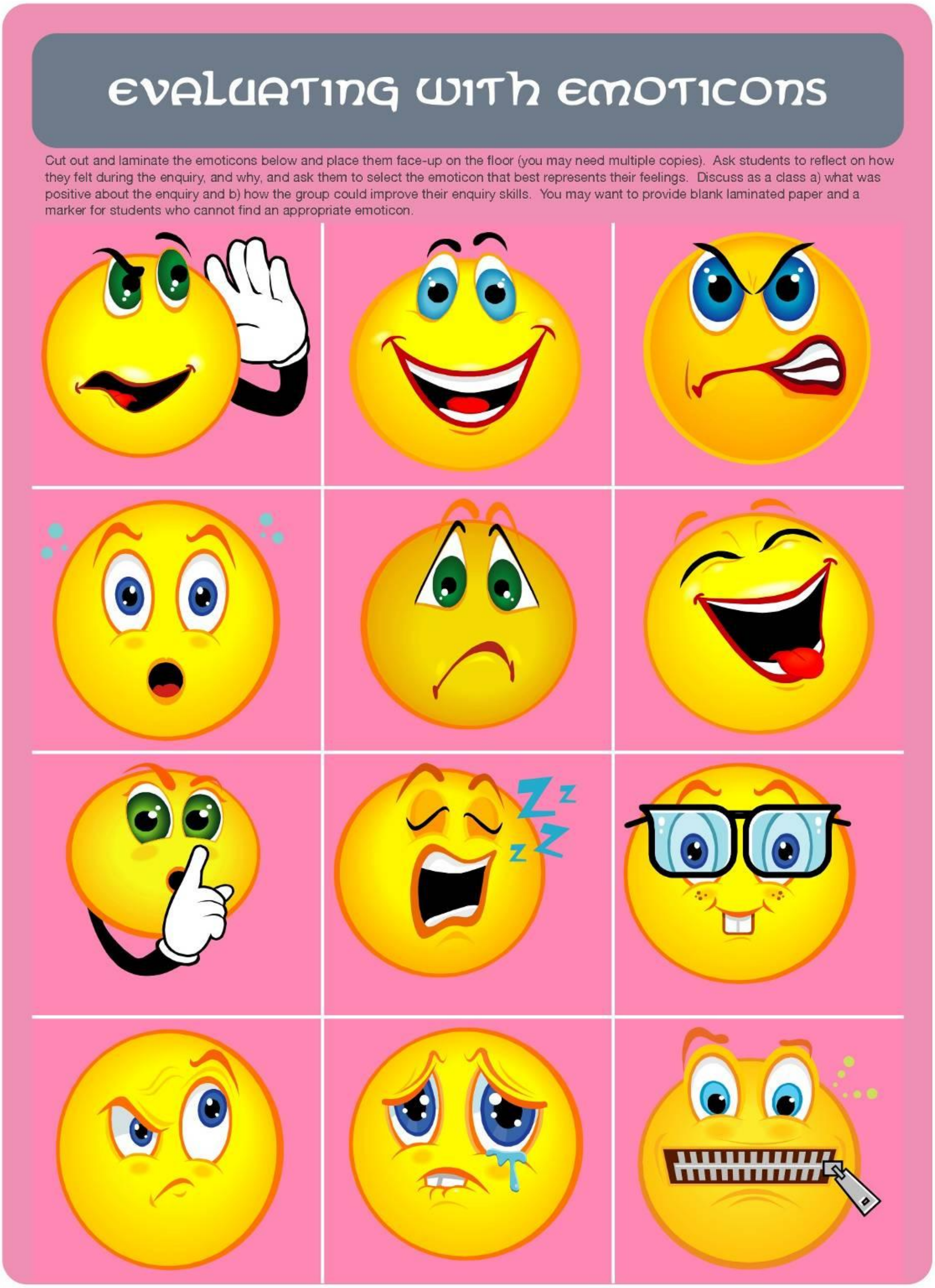
ANTIBIOTIC USE QUIZ

To answer yes, students make a Y with their bodies by raising their arms in the air, to answer no, they make a cross with their arms, and to answer don't know, they shrug their shoulders. Go through correct answers as you play.

ARE ANTIBIOTICS EFFECTIVE AT TREATING BACTERIAL INFECTIONS? ANS: YES	ARE ANTIBIOTICS EFFECTIVE AT TREATING VIRAL INFECTIONS? ANS: NO	SHOULD YOU STOP TAKING ANTIBIOTICS WHEN YOU FEEL BETTER? ANS: NO - FINISH THE COURSE
IS MRSA AN ANTIBIOTIC? ANS: NO - IT IS A BACTERIA.	IS PENICILLIN AN ANTIBIOTIC? ANS: YES	DO ANTIBIOTICS ALWAYS KILL BACTERIA? ANS: NO - THEY ALSO STOP THEM DIVIDING
DO BACTERIA EVOLVE? ANS: YES	YOU ARE ILL. YOUR MUM TELLS YOU TO TAKE HER LEFTOVER ANTIBIOTICS. SHOULD YOU? ANS: NO	ARE ALL BACTERIA HARMFUL TO HUMANS? ANS: NO

 [2] www.ulster.ac.uk/scienceinsociety/

Figure 1 (c): Activity for evaluating the enquiry and setting targets for the next session.



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Religious Education, Technology and English. 54% of participants were in year 8 (the first year of post-primary education), 22% in year 9 and 24% in year 10.

Data Collection

Work with each group involved between 6 and 8 Forward Thinking sessions. Each session consisted of the following stages: preparation for the enquiry; sharing stimulus material; reflecting on the stimulus, generating questions, sharing and airing questions, voting, enquiry, reflection on the enquiry and last words. The topics were agreed with teachers in advance: some schools requested sessions on a single theme (e.g. astronomy) or topic (e.g. cloning). At the end of the last session, participating students present and their teacher were asked to complete a written evaluation questionnaire.

Studentswere asked to evaluate each session informally (e.g. using interactive handsets or exit tickets asking students to identify knowledge gained and skills used in the session) and to complete an evaluation questionnaire on the final session. Teachers were asked to observe and/or participate in the sessions and to complete a final evaluation questionnaire. A reflective diary was kept by the researcher.

Analysis

Evaluation data was analysed using SPSS. A Mann-Whitney test was used to test for differences between children in selective/non-selective schools and a Kruskall-Wallis used to test for significant differences between young people in girls'/boys'/mixed schools and for those in the first/second/third years of secondary education.

RESULTS

Student evaluations

A total of 260 student evaluations were collected (response rate 86%). Students found the Forward Thinking project interesting (90 % of respondents) and enjoyable (93% of respondents) and have reported that the project was useful to help them learn science (90 % of respondents), think of social and ethical questions related to science (80%) become aware of other people's ideas and opinions (83%) and to think about how they can improve (86% of respondents). Furthermore, children were likely to carry on their discussions about these topics outside the classroom (73% of respondents).

Students in single sex schools were signigicantly more likely to think that the sessions helped them to improve their scientific knowledge (p=0.001; Kruskal-Wallis,□ □ [2] = 13.908), to enjoy the Forward Thinking sessions (p=0.001; Kruskal-Wallis,□ □ [2] = 14.757), to assert that this approach helped them think about how to improve (p=0.000; Kruskal-Wallis,□ □ [2] = 27.229) and made them aware of other points of view (p=0.006; Kruskal-Wallis,□ □ [2] = 10.315) and of different ideas (p=0.000; Kruskal-Wallis,□ □ [2] = 17.722). Students in boys' schools were most likely to say that the sessions made them aware of different ideas and other points of view, followed by those in girls' schools. There were no significant differences in terms of students' likelihood to talk about the topics outside class, or their interest in the Forward Thinking sessions.

Older students (in years 9 and 10) were significantly more likely to say that the sessions helped them think about how to improve (p=0.004; Kruskal-Wallis,□ □ [2] = 11.106) but there were no significant differences in whether they enjoyed the sessions, found them interesting or thought the Forward Thinking sessions helped them to learn science.

Informal evaluation is an integral part of the community of scientific enquiry. For example, on the topic of cloning, students were asked to complete an exit ticket which asked them what knowledge they had gained and what skills they had used during the session. Knowledge gained included that clones are not belly-buttonless (a common misconception in one class), how cloning takes place, that there are several ways to produce clones, the consequences of human cloning, what stem cells are, that a human clone would not be the same age as the parent, that animals have been cloned, that human reproductive cloning is illegal in the UK and about the "good and bad" aspects of cloning. Skills that students identified using included listening, speaking, observing, sharing, thinking, group work, debating, making points clearly, discussing, reasoning, concentration and expressing opinions.

A subset of 18 students at one school were asked to select which part of the session on cloning helped them understand the topic best. They were asked to select from an interactive quiz (using TurningPoint handsets), a jelly model demonstrating cell nuclear transfer, the "Weird Al" Yankovic song and music video for I Think I'm A Clone Now, and the enquiry itself. 17% responded that the quiz had helped most, 11% the jelly model, 11% the song and 61% the enquiry.

Teacher evaluations

Six evaluations were returned from teachers who were present for sessions with their class. (the low response rate reflects the fact that some teachers were not present for more than one session, e.g. in schools were the project was delivered through different curriculum subjects; two teachers who were present for all sessions did not return the questionnaires). All six reported finding this approach useful for delivering the curriculum, for helping their students think about social and ethical issues relating to science and reported that the sessions helped to develop their students' thinking skills, scientific knowledge and social skills, particularly in more reticent pupils. Teachers were provided with access to resources for use in a Community of Enquiry (available on http://www.ulster.ac.uk/scienceinsociety/forwardthinking.html). Six teachers were trained in the use of the technique in November 2009 and others will be invited to attend a training event in 2010.

CONCLUSIONS

This approach shows potential for longer term use in secondary science as a way of engaging students with science and the associated social and ethical issues, identifying misconceptions and for promoting thinking skills as well as scientific knowledge and understanding. Although the limitations are that by handing over the selection of questions to students, it cannot be guaranteed that students will cover a specific part of curriculum content knowledge, there are opportunities to widen learning beyond the curriculum, link meaningfully with other subjects and with everyday life and for students to become more engaged with their own learning.

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WORKING WITH SOCIO-SCIENTIFIC ISSUES – STUDENTS' AND TEACHERS' EXPERIENCES

Margareta Ekborg
Malmö University
Margareta.ekborg@mah.se

Christina Ottander
Umeå University
Christina.ottander@matnv.umu.se

The project is funded by the Swedish Research Council. The research group is called SISC (Science in Social Contexts) consists of Britt Lindahl and Maria Rosberg at Kristianstad University, Margareta Ekborg, Christina Ottander, Eva Silfver and Mikael Winberg at Umeå University, and Malin Ideland, Claes Malmberg and Agneta Rehn at Malmö University (www.sisc.se).

ABSTRACT

We present a research project aiming at investigating how teachers and students in lower secondary school experience work with socio-scientific issues (SSIs). Our interest concerns the importance the actual content has for the students' interest and learning and how students' gender and attitudes towards science, affect their experience. Another interest is how the teachers describe their work with the cases, the students' learning and what difficulties they encounter in the work. We have compared students' and teachers' experiences of the SSI work. Data have been collected by questionnaires with students and teachers and interviews with teachers. The teachers confirm results from this and other studies that students are interested in working with socio-scientific issues. However some of results are contradictory. The teachers felt safe with content and work forms but they still arranged SSI as something special and even if they were comfortable with group work they generally did not seem to know how to facilitate the students' work. Both students and teachers found the work interesting and the teachers but not the students judged that the students learnt as much science as usual. Both students and teachers perceived critical thinking, search for information, and ability in argumentation as learning outcomes that were developed during the work with the case

Keywords: *Socio-scientific issues, secondary school, teachers, students, authentic cases*

INTRODUCTION

In this paper we report the results from a study of how students and teachers experience work with a number of socio-scientific cases constructed for this research project.

There are several arguments for making changes in secondary school science. Firstly, students often express interest in science but they find science in school difficult and without relevance for them (Lindahl, 2003). They are critical about both the content of the school subject and to how it is taught. The students feel that the content is set and that there is nothing to discuss, unlike other school subjects such as history and religious education. During the later years of compulsory school the interest decreases. For a long time this has been most obvious for girls but now it is becoming more common among boys as well

(Lindahl, 2003) At the same time, the students feel that they are not doing well in science - even if they have good marks. This is not the case for other school subjects (Lindahl, 2003; Osborne, Simon, & Collins, 2003). Results from the ROSE project – Relevance of Science Education indicate that there is a gap between what students are interested in learning about and what is taught in school (Oscarsson, Jidesjö, Karlsson & Strömdahl, 2009). It is also most obvious for chemistry and physics. New strategies for increasing young peoples' interest and knowledge in science and their ability to use science outside school are needed (Osborne & Dillon, 2008) to provide students with the knowledge they need for life in a modern society.

Secondly, the Swedish curriculum and syllabuses for science state that students should develop knowledge not only in scientific content but also in knowledge *concerning scientific activity* and knowledge *concerning the use of knowledge* (Skolverket, 2000). However, according to the latest national evaluation (NU03), these last two aspects seem to be taught to a lesser extent in school (Skolverket, 2005). Also, international studies show that many teachers teach the scientific content in preference to the nature of science (Sadler, Amirshokoohi, Kazempour & Allspaw, 2006). Unfortunately NU03 also shows that many students do not reach the goals for conceptual understanding, as described in the national course syllabuses in science for school year nine (Skolverket, 2005). In other words, students in general find science boring and difficult, they are not taught what is stated in the curriculum and they do not reach a satisfactory level in what they actually are taught.

Work with SSIs can be a means of overcoming some problems with school science: to raise interest in science, to cover all aspects of the curriculum, and to involve a more interactive and dialogic pedagogy. Some general characteristics of SSIs are: they are important for society, have a basis in science, involve forming opinions, are frequently media-reported, address local, national and global dimensions with attendant political and societal frameworks, involve values and ethical reasoning, may involve consideration of sustainable development and may require some understanding of probability and risks, and there are no ”right” answers (Ratcliffe & Grace, 2003). To work with SSI means to work with content both *in* science and *about* science, as stated in the Swedish curriculum. SSI are said to be vehicles for strengthening generic skills as team-work, problem-solving and media literacy (Ratcliffe and Grace, 2003). Decision-making and argumentation are also important in work with SSI. Research has revealed that such issues challenge students' rational, social and emotional skills (Sadler, 2004) and other studies show that students are interested in working with issues with a more humanistic perspective (Aikenhead, 2006). However, several problematic factors are identified, such as that the students can easily be distracted when they are working with complex issues where the outcome often is not clear (Zeidler, Sadler & Simmons, 2005). Aikenhead (2006) argues that issues with a humanistic perspective are often complex, and therefore difficult to understand. Sadler, Barab and Scott (2007) state that significant work remains in order to ascertain the link between SSI curricula and the learning of science content.

Research shows that teachers find it difficult to teach SSI as well as argumentation. The problem does not seem to be the content in itself, but rather to teach ideas about science and to conduct teaching which includes decision-making and argumentation (Gray & Bryce, 2006). Newton, Driver and Osborne (1999) report, that teachers often do not have faith in their ability to conduct teaching in which the students engage in argumentation. Teachers also feel insecure in to what extent they should be involved themselves in the classroom discussions and to handle the anxiety or emotions caused by, for example, work with gene technology (Bryce & Gray, 2004). Teachers also experience tension between educational arguments for devoting time to developing students' understanding of scientific processes and the classroom reality (Bartholomew, Osborne & Ratcliffe, 2004). Most teachers have inadequate ideas *about* science and there is a complex relationship between teachers' stated beliefs about science and how they actually present science in their classrooms (Abd-El-Khalic & Lederman, 2000).

Aim

We present a research project aiming at investigating how teachers and students in lower secondary school experience work with socio-scientific issues (SSIs). Our interest concerns the importance the actual content has for the students' interest and learning and how students' gender and attitudes towards science, affect their experience. Another interest is how the teachers describe their work with the cases, the students' learning and what difficulties they encounter in the work. We have compared students' and teachers' experiences of the SSI work.

The aim is operationalized in the following research questions:

- What cases did the teachers select?
- How interesting do boys and girls find the different cases?
- What are the teachers' and the students' opinions about the cases and how do the cases differ concerning how students judge currency, relevance of the task, and how difficult or easy the content and the task is?
- How do teachers describe their work with SSI cases in terms of students' work and learning?
- To what extent do SSIs provide opportunities for learning as perceived by students?
- What similarities and differences are there between teachers and students?

METHODOLOGY

In Ekborg, Ideland, and Malmberg (2009), we describe a conceptual framework consisting of six components chosen to describe the characteristics of SSIs. The components are: starting point; school subject; nature of scientific evidence; social content; use of scientific knowledge and level of conflict. The purpose is to use it as a research tool for the analysis of different dimensions in pupils' work with socio-scientific issues. The intention is to connect outcomes in learning and interest to the different components. We constructed six cases in which these components vary. All cases were current and authentic: that is, we have used real situations and neither rewritten nor adapted the original starting points of the case. In Sweden, school science is defined as the following subjects; biology, chemistry and physics. As issues related to health or the environment are usually of interest to the general public (Ratcliffe & Grace, 2003), the six cases were chosen so that the subject content is a combination of a doorway into an interdisciplinary topic, and traditional school science. The scientific content includes concepts, theories and processes that are found in most science syllabuses all over the world. However, the framework does not contain information about specific science content such as concepts and processes or suggests content *about* science. A teacher's guide was then developed (www.sisc.se)

The Swedish syllabuses are goal-driven and not very detailed, which has the consequence that teachers are free to choose content and teaching methods as long as their students reach the goals (Skolverket, 2000). It also means that it is almost impossible to give detailed instructions to Swedish teachers and expect them to be followed, as teachers are used to organize the work as they find appropriate themselves.

Sample

70 teachers with approximately 1500 students in Sweden volunteered to work with our SSI cases and each teacher chose one case. A questionnaire was used to measure students' attitudes towards and interest in science before starting to work with the case and a second

questionnaire (N=1100) after finishing a case. 55 teachers answered a questionnaire after the work and seven of them were then interviewed.

Questionnaires

This study is part of a larger study and therefore the questionnaires for students as well as for teachers include a rather large number of items. Here we only describe those that are relevant for this paper. The first student questionnaire aimed at describing the pupils' personal characteristics from several aspects. It included questions about gender, learning goals, attitudes toward science in school and society and beliefs about learning. The second student questionnaire, measured the situational characteristics of the SSI work and its perceived cognitive and affective outcomes and it was completed immediately after an SSI activity.

The teachers' questionnaire included questions about background information and there were three open-ended questions about students' reports, assessment and one question in which the respondents were free to write comments. The statements were chosen to get a brief overview of how different teachers organized the work and what their experiences were. The questions were organized in the following groups: Information about the teacher, the class and choice of case, The teachers' opinions about the case, How the classroom work was organized, Opinions about the students when working with the case, Opinions of different aspects of the students' learning, Reporting on what the students based their arguments on, Resources used by the students and The teachers' personal experience.

All questions (except gender) in the student questionnaires and most questions in the teacher questionnaire used Likert scales with five steps where 1 is *disagree* or *not at all* and 5 is *fully agree* or *to a great extent*, depending on the statement. Likert scale are arbitrary in the sense that we do not know the exact amount of interest or agreement but we assume that the respondents interpret the distances between each of the categories as equal sized intervals. One advantage of consider the scale as an interval scale is that it can be used in the most common statistical procedures (Ary, Jacobs and Razavieh, 1996). The data from the questionnaires were exported to an SPSS™ file. Descriptive statistics - frequencies, mean values, median and cross tabs were used. To test the statistical significance chi-square distribution were calculated. We have also done a Kruskal-Wallis test by comparing the answers for attitude, interest and sex as an analysis of significance.

Interviews

Semi-structured interviews were conducted with one teacher at a time. In the interviews the teachers were asked about: choice of case - why and alternatives; work with the case – detailed discussions about planning the work, about reasons for different choices and about outcome; personal reflections about the case - possible development of cases and influence on teaching. All interviews were recorded and transcribed verbatim.

Firstly, we identified some basic information about the teachers. Then the transcripts were read through several times. The analysis was performed in several steps. We started by coding what the teachers said about the case – content, both in and about science, work forms and outcome and what teachers said about science teaching in general. Based on this coding, we described how each one of teachers worked with the case and how they motivated their choices. We then saw some patterns which we further investigated by coding the transcripts according to beliefs about SSI, school science and how students learn.

RESULTS

In almost all classes the teacher chose which case to work with. Only in a few classes the students were involved in choosing case. Most chosen, with more than 350 students, were the cases *Me, my family and global change* and *You are what you eat* followed by *Are mobiles hazardous* with 200 students and *Laser treatment and nearsightedness* with 100 students. Two classes worked with the case *To hear or not to hear* and only one class with *Climate friendly food.*

The majority of students in this study is positive to school and describe themselves as *be doing well at school*. Less than 50 percent of the students describe themselves as interested in science, with boys and girls expressing a similar view. Approximately 20 % find school science difficult and again there is no significant difference between the sexes.

According to the students, all cases except one were interesting (table 1). There was a significant difference between how interesting the students found the different cases. The most interesting case was *Are mobile telephones hazardous.* Both boys and girls found that case interesting. It was followed by *Laser treatment and nearsightedness* and *You are what you eat*. In each of these cases, half of the student group agreed to the statement that the case was interesting and approximately 20 % disagreed. The only case that was not interesting was *To hear or not to hear* where approximately 25 % of the students found it interesting and almost 40 % disagreed. The case *You are what you eat* was more interesting according to the girls. Both Chi-square and the Kruskal-Wallis test show a significant difference between how girls and boys judge that case. The Pearson Chi-Square has a value of 18.123 (at 4 degrees of freedom) and a p-value of 0.001. All other cases were gender neutral.

Table 1. Girls' and boys' judgment of how interesting the cases were. The questionnaire used a Likert scale with five steps between disagree and agree. In this table steps 1+2 and 4+5 are merged together and instead of actual number of students the percentage is reported. The percentages are shown to facilitate comparison, however, the Pearson Chi-Square value is calculated from the frequencies on the five steps in the Likert-scale. The p-value is a measure of the statistical significance.

Case	Sex	N	The case was interesting			Pearson Chi^2 and p-value
			Disagree %	Midway %	Agree %	
You are what you eat	Girls	178	17.4	25.3	57.3	18.123
	Boys	182	28.6	31.9	39.6	0.001
Laser treatment and nearsightedness	Girls	64	17.2	32.8	50.0	0.056
	Boys	53	18.9	32.1	49.1	0.973
To hear or not to hear?	Girls	14	35.7	35.7	28.6	0.221
	Boys	23	39.1	39.1	21.7	0.896
Me, my family and global warning	Girls	202	27.2	29.7	43.1	1.006
	Boys	172	26.2	26.7	47.1	0.909
Are mobiles hazardous?	Girls	106	19.8	21.7	58.5	8.466
	Boys	101	21.8	26.7	51.5	0.076
Climate friendly food	Girls	11	27.3	45.5	27.3	2.369
	Boys	5	0	40.0	60.0	0.306

Both the students and the teachers found the SSIs to be current topics with interesting content and relevant tasks (table 2 and 3). According to the students all but one case had an average value above 3 in the aspect of how interesting the case was, and all had an average value above 3 in the aspects of currency. Furthermore the statistical test, i.e. Pearson Chi-Square values (X) and the p-values (*), show a significant difference between how the different cases were judged by the students (table 2). The cases differ concerning how students judge currency, relevance of the task, and how difficult or easy the content and the task are. The case *Me, my family and global warming* was considered the most up-to-date followed by *Are mobile phones hazardous.* The case *Climate friendly food* and *To hear or not to hear* were not so current according to the students. There was also a significant difference in how easy the students experienced the tasks of the different cases (table 2). The case You are what you eat was considered to be the easiest task and Me, my family and global warning the most difficult task. Overall the students considered the assignments easy to solve with no significant difference between boys and girls in aspects of how easy or current the case was. The teachers considered the content appropriate in relation to the syllabuses, but what is interesting is that they teachers did not, to the same extent, find them appropriate in relation to the students' prior knowledge (mean value 3.1).

Table 2. Students' judgment of the cases; how they value the content and the task in each case. The figures are mean values (average scores) from the 1-5 Likert scale used in the questionnaire where 1 is disagree and 5 is agree. X= the Pearson Chi-Square value and * represents a p-value of $p<0.05$ and ** a p-value of $p<0.01$

Case	N	The case was interes-ting X= 18.59*	Assign-ment related to a current issue X= 63.46**	It was fun to discuss the question X= 32.44*	The assign-ment was easy X= 48.96**	The assign-ment was boring X=22.94
You are what you eat	364	3.32	3.63	3.21	3.43	2.81
Laser treatment and nearsightedness	117	3.40	3.52	3.59	3.21	2.7
To hear or not to hear?	37	2.81	3.33	2.86	3.22	3.51
Me, my family and global warning	379	3.28	4.04	3.27	3.09	2.9
Are mobiles hazardous?	209	3.46	3.71	3.53	3.22	2.78
Climate friendly food	16	3.31	3.24	3.29	3.41	2.75

Table 3. How the teachers value the introduction of the case, the content and the task in each case. The figures are mean values on a scale 1-5 where 5 is agree to the different statements.

Case	Introduction Mean value	Content Mean value	Task Mean value
1. You are what you eat	4.5 (0.6)	4.5 (0.6)	3.8 (0.7)
2. Laser treatment and nearsightedness	3.8 (0.5)	4.3 (0.5)	3.8 (1.3)
3. To hear or not to hear?	4.0 (1.4)	4.0 (1.4)	4.5 (0.7)
4. Me, my family and global warming	3.7 (1.4)	3.7 (0.8)	3.6 (0.9)
5. Are mobile phones hazardous?	2.8 (0.5)	3.8 (0.5)	3.8 (0.5)

The teachers felt confident with the work with the cases. Most common was that the students worked in groups (mean value 4.2). Notable is that lab work was not common when working with the cases (mean value 1.8). Some teachers commented on the lack of lab work, e.g. "It was difficult to find appropriate labs so that it became more theoretical than usual science classes" (teacher number 9). Another reason for not doing lab work was that many teachers worked with the case outside regular science lessons, for example in a special week set aside for thematic work and without access to laboratories. Approximately 40% of the teachers taught part of the topic before introducing the case, which means that they did not use the case to teach new science content. More than half of the teachers chose to present goals from the teacher's guide to the students in the beginning of the work.

Even though SSI cases are about current topics debated and written about in media, the students did not use traditional media for information search to a great extent (mean value 2.6). The most common source was the Internet (mean value 4.1). They also used textbooks (mean value 3.9) and to less extent resources outside school, such as study visits or interviews (mean value 1.3). The teachers' answers also indicate some problems e.g. the students did not easily formulate questions, critically examine arguments or use media for more information about the task. The students did not find it difficult to search for information about the cases. Also, in all cases the students were satisfied with what the different students accomplished during the group work. They found the discussion and each other's standpoints important and perceived that the outcome of working with case had relevance for them. The average score for the girls was somewhat higher on the statement: it was fun to discuss the questions in the assignment. Similar to the teachers' opinion the students also report that the work forms used were quite similar to their regular teaching. The major difference is that in very few classes laboratory work was included when working with SSI.

Learning

We also wanted to know to what extent SSI provide opportunities for learning. Most teachers based their assessment of learning outcome on the presentations, which meant that they assessed oral group discussions and presentations. Few teachers did individual assessment. Even if the work was not assessed individually the teachers found that the students developed critical thinking, learnt to search for information, learnt scientific facts, learnt to apply scientific knowledge, developed understanding of science, and developed ability in argumentation (Table 4). Even if the seven teachers talked differently about teaching and learning, the object for teaching and learning is learning facts. All interviewed teachers, explicitly or implicitly, talked about knowledge as a set of facts which should be taken in by the students.

Table 4. Teachers' responses to statements about students' learning

The students learnt/developed	Mean value
critical thinking	3.7 (1.2)
to search for information	3.6 (1.2)
scientific facts	3.6 (1.3)
to apply scientific knowledge	3.6 (1.3)
ability to argue	3.4 (1.3)
understanding in science	3.5 (1.3)

Almost all students claimed that they learnt new facts during the work (table 5). The case *Laser treatment and nearsightedness* was considered to be the case in which the students developed most new knowledge according to their own judgment. The students reported that they learnt to argue for their standpoint and to search for and scrutinize information. Noteworthy is that the average value of the students self-reported learning outcome is higher for the statement 'learning new facts' than for 'learning science', even though the case was dealt with during science class. Neither did the students claim that they learnt more science than during regular lessons. There was a significant difference between the cases when it comes to how students perceived ‘learning facts’, ‘deal with information’ and ‘argue for an opinion’ but there was no significant difference between the cases when it comes to learning science. The students considered the case *Laser treatment of nearsightedness* as developing most new knowledge, also in science, and also in developing their argumentation skills. It was the case *Are mobiles hazardous?* that developed searching for and scrutinizing information most. The case *To hear or not to hear* were perceived as giving lower learning outcomes on all aspects.

Interpretation of SSI

All the teachers have ideas about connecting school science to reality, but they have not encountered the concept of SSI before. This raises the question of how they interpret the meaning of socio-scientific issues. It was most common that the teacher choose a case that fitted with content that was already planned to be taught. When working with the case the teacher uses the starting point to introduce the content, but does not introduce much new content. It is supported by the result that media and resources outside school are not used to find information. However, they did not automatically fit all the regular school content in these cases, e.g. few included common school labs. The fact that only one of the seven interviewed teachers included lab work can be interpreted as if it is not common to answer questions by doing experiments.

Table 5. Students self-reported learning outcome. The figures are mean values (average scores) from the 1-5 Likert scale used in the questionnaire where 1 is disagree and 5 is agree. X= the Pearson Chi-Square value and * represents a p-value of p<0.05 and ** a p-value of p<0.01

Case	I have learnt new facts X=45.54**	I have learnt to search information X=35.86*	I have learnt to scrutinize information X=32.99*	I have learnt to argue for my opinion X41.14**	I have learnt science X=24.23	I have learnt more than in regular classes X=21.40
You are what you eat	4.0	3.3	3.4	3.7	3.5	2.8
Laser treatment nearsightedness	4.5	3.5	3.5	4.1	3.7	2.7
To hear or not to hear?	4.0	3.0	3.2	3.7	3.3	2.3
Me, my family and global warning	4.0	3.4	3.2	3.7	3.5	2.8
Are mobiles hazardous?	4.2	3.7	3.6	4.0	3.5	2.7

The teachers do not express anything which can be interpreted as evaluating or discussing observations and results. However, there are some indications that the teachers reflect on some of these aspects. One teacher for example, discovers that different websites give different results when calculating amounts of carbon dioxide emissions. When he thinks about it again, he thinks this is a good thing because then he can talk with his students about these differences and why they occur. Another teacher dares to choose *Are mobile telephones hazardous?* and she is well aware of the fact that the information about radiation and health is contradictory. Several teachers talk in general terms about the importance of learning how to use and apply scientific knowledge, but they are vague and they do not give any examples.

CONCLUSIONS AND IMPLICATIONS

This study confirms results from other studies that students are interested in working with socio-scientific issues (Sadler, 2004; Aikenhead, 2006). However the teachers in this study do not seem to be as concerned as the teachers in Bryce and Grays study (2004) about teaching argumentation and decision making. They did not feel the tension between devoting time to developing students' understanding of scientific processes and the classroom reality (Bartholomew et al., 2004). Instead they found the cases interesting and felt safe with work forms such as group work as well as with the content. They answered that the students learnt as much as during ordinary teaching.

The students did not learn as much science as in ordinary lessons according to their own judgement and they found cases interesting, however they did not find them as interesting as the teachers did. Taking into account that the teachers commented in the questionnaires and talked more elaborated in the interviews about problems with the students' questioning and ability to critically examine media it is reasonable to believe that the work has been rather inefficient. Probably the students have not been properly facilitated, which explains the perceived learning by the students. Another reason for that the students do not find the work as interesting as the teachers do might be that almost none of the teachers included lab work. Even if the students did not learn more science than usual they perceived that they learnt some aspects of science e.g. more facts and to argue. This is in line with our interpretation of the teachers' understanding of knowledge. The idea is to deliver a set of facts to be taken in by the students.

Both teachers and students indicated that group work had been common and that there had been lots of discussion. Especially the girls appreciated the discussions. Reflecting these results with the students' perceived learning it is interesting to note that the students indicate that they learnt to argue but they did not learn more science. So what is their idea of what learning science is about? Maybe it takes some time to get discussions, argumentation etc. to work in way that feels rewarding and is understood as learning opportunities by the students. We believe that teachers need to develop strategies for facilitating group discussions.

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BRIDGING THE RESEARCH-PRACTICE GAP IN SCIENCE EDUCATION WITH A VIRTUAL COMMUNITY OF PRACTICE (COMPRATICA)

Charbel Niño El-Hani

Dept. of General Biology, Institute of Biology, Federal University of Bahia.
Rua Barão de Jeremoabo, s/n – Ondina, Salvador-BA, Brazil. ZIP: 40170-115.

e-mails:charbel@ufba.br, charbel.elhani@pesquisador.cnpq.br

Ileana M. Greca

Dept. of Physics,
University of Burgos, Spain.

e-mail: ilegreca @hotmail.com

ABSTRACT

This paper reports results from a virtual community of practice (ComPratica) used as a tool for bridging the research-practice gap in biology education. ComPratica gathers in-service high school teachers, preservice teachers, researchers, and graduate and undergraduate students. It includes forums and chats about matters related to science education, and has as a central activity the construction of collaborative action research, situated in real classroom conditions, involving teachers and researchers in non hierarchical teams. The initial success of the community is indicated by the high degree of participation of its members, the diversity of themes addressed in the forums, and the development of action research projects focused on the high school teachers' classroom, mostly focused on issues raised by the teachers themselves. In this paper, we describe the community of practice, discuss data concerning the members' participation, and offer a thematic analysis of the messages sent in its forums.

Keywords: *Community of practice, Professional development, Research-practice gap, Teacher education.*

THE RESEARCH-PRACTICE GAP: AN EPISTEMOLOGICAL ISSUE

A research-practice gap is generally recognized by educational researchers and teachers (e.g., Kennedy 1997; McIntyre 2005), and it is also a problem in science education (Pekarek, Krockover and Shepardson 1996). Kennedy (1997) discusses four hypotheses proposed to explain the perceived lack of connection between research and practice: (1) research is not sufficiently authoritative and/or persuasive, as a consequence of limits in its non experimental methodology; (2) research needs to be more relevant to teachers' concerns and classroom work; (3) research needs to be more accessible to teachers; and (4) the education system itself is either too stable or too unstable to be able to respond coherently to research findings.

The first hypothesis considers that educational studies have not shown enough quality to provide compelling, unambiguous, or authoritative results to practitioners. Even though it is currently not very relevant to understand the research-practice gap, this was the characteristic approach to this problem since the 1940s until the post-Sputnik era, in the 1960s. The debates were focused on research designs that might be capable of improving the quality of educational studies. Experimental or quasi-experimental approaches were thought to be necessary and, consequently, there was great concern with the isolation and control of variables. Since the mid-1970s, however, it became widely accepted that research is more likely to be relevant to educational initiatives and practices if it is performed in school and classroom settings, not in labs. We still worry, of course, about research design and knowledge reliability, but we ended up accepting that strict control of variables is impossible in most, if not all, classrooms.

The second hypothesis concerns the lack of relevance of research to teaching practice and is usually related to the limited interest of researchers in addressing teachers' questions, or acknowledging the constraints that act upon teachers' pedagogical work. Kennedy (1997, p. 5) mentions a "dilemma of relevance", which prompts us to put into question the very meaning of "relevance". This dilemma calls attention to the differences between the kind of knowledge built by teachers for use in their practices and the kind of knowledge produced by educational research. In view of these differences, it is not likely that educational research offers the recipes for teaching that, sometimes, teachers are expecting.

The meaning of the "relevance" of research to practice should be questioned from the standpoint of both teachers and researchers. The dilemma of relevance can be partly solved by a process of teacher education with regard to the nature of research and research-based knowledge. Moreover, reflective practice is also another avenue for solving the problem of relevance. Researchers, in turn, need to focus on questions resulting from the needs and concerns of teachers and other actors of the school system (Hargreaves 2000).

If research-based findings are to be used by teachers in the construction of, and reflection upon, their practices, they should be presented in an accessible manner. This is the central idea in the third hypothesis discussed by Kennedy. Research-based knowledge should be accessible in two senses; first, it needs to be available for teachers by means of journals aimed at a teachers' audience, internet resources, etc. Second, and more importantly, it is fundamental to present research-based knowledge in an accessible manner, with regard to teachers' understanding. That is, what is at stake is not only physical accessibility, but, most of all, conceptual accessibility. This leads, however, to another dilemma, since we tend to regard an idea as relevant and accessible if it shows a certain degree of agreement with our system of beliefs (or conceptual ecology). Consequently, research-based knowledge that is conceptually accessible to teachers may be research that does not challenge their presuppositions or introduce new possibilities (Kennedy 1997).

Changes in teaching practice will not follow, thus, from the simple act of informing teachers about research results. The dilemmas related to the relevance and accessibility of research can be discussed in terms of the necessity of framing research-based knowledge in an epistemological form that is more accessible to teachers and more in agreement with the reality of their work and knowledge.

These three hypotheses assume that research might influence practice if one could improve the methods, research questions, dissemination, or some other characteristic of academic work. The fourth hypothesis is more pessimistic, suggesting that several features of the educational systems hold back the influence of research over teaching practices. These systems would be either too stable and, thus, incapable of changing, or inherently instable, because of their susceptibility to passing fads. In one way or another, they would be incapable of answering in a coherent manner to educational research. Maybe this hypothesis is warranted, but simply to accept it may incline us to abandon our role of participants in an unceasing debate about the improvement of education. It is better, thus, to avoid taking this hypothesis at face value and go on with our attempts to bridge the research-practice gap.

McIntyre (2005) puts forward a different perspective on the research-practice gap, which can be connected with Kennedy's arguments about relevance and accessibility. From this perspective, the gap is primarily seen as a problem of relating two contrasting kinds of knowledge, which are at the opposite ends of a spectrum of kinds of knowledge related to classroom teaching and learning. Teachers' everyday work demands a kind of pedagogical knowledge that is very different from the knowledge that educational research is well equipped to provide. By 'pedagogical knowledge', we mean the knowledge that directly informs teachers' practice in managing classrooms and mediating students' learning. This is 'knowledge 'how' and is very different from the kind of knowledge to which research typically leads, which is propositional knowledge, i.e., 'knowledge that' (McIntyre 2005). Since research-based propositional knowledge cannot be simply translated into pedagogical knowledge, several steps are needed to bridge the gap between them. These steps from academic knowledge to practice, and from practice to academic knowledge, will become much easier if teachers and researchers are brought together in truly collaborative teams. In this manner, we will be in a better condition to make research-based knowledge accessible to teachers, even in cases in which their beliefs are challenged by findings and ideas about teaching and learning that seem counter-intuitive.

We believe that the research-practice gap should be a major worry for all educational researchers. Accordingly, we have been actively looking for ways of overcoming it in our own work. In this paper, we report results obtained in the construction and investigation of a community of practice (named ComPratica) that aims at bridging the research-practice gap.

COMMUNITIES OF PRACTICE AND THE RESEARCH-PRACTICE GAP

A community of practice (CoP) is defined by Lave and Wenger (1991) as a group of individuals with distinct sets of knowledge, abilities and experiences, who are actively involved in collaborative processes, sharing information, ideas, interests, resources, perspectives, activities, and, above all, practices, in order to build both personal and collective knowledge (see also Wenger 1998). When a CoP is effectively working, it generates and appropriates a shared repertoire of ideas, goals, and memories. It develops resources, such as tools, documents, routines, vocabularies, and symbols, which bring with them, to some extent, the knowledge built up by the community. In other words, a CoP involves praxis: shared ways of doing and approaching those things that are of interest to the people who constitute it. The concept of CoP is derived from a view of learning as a social rather than individual process. From this perspective, in order to learn one needs to participate, actively becoming involved in social processes, resituating (and not only translating or transposing) the meaning of formal descriptions and prescriptions while carrying out a given task.

Sociological and anthropological researches have documented the characteristics of CoPs and how their members work together and build their relationships (Lave & Wenger 1991; Wenger 1998; Brown and Duguid 20000). CoPs have also been the subject of extensive and relevant debate, focusing, for instance, in issues of language and power inside them (Barton & Tusting, 2005), or how CoPs' members can go beyond sense-making, involving a restricted form of reflective learning, towards critical reflective learning (Ng & Tan, 2009). CoPs have been increasingly seen as adequate tools for teachers' professional development. Consequently, a number of relatively recent applications have appeared, such as CoT, a teachers' community which functions as a preparation program for preservice teachers working towards secondary teacher certification (Barab, Barnett and Squire, 2002), the online CoP Tapped In (Schlager, Fusco and Schank, 2002), and Connect-Me, a virtual community of practice for mathematics teachers (Dalgarno and Colgan, 2007). CoPs can potentially catalyze the double movement from academic knowledge to practitioner knowledge, and vice versa, required to diminish the research-practice gap. That's why we engaged in building and investigating a CoP, named ComPratica, as a way of bridging this gap.

ComPratica includes high school in-service biology teachers, preservice biology teachers, science education researchers and graduate students, and undergraduate and graduate biology students. It is a virtual community of practice, implemented in the Virtual Learning Environment Moodle™ (http://moodle.org), a reliable and user-friendly platform, which is implemented in our university, is entirely in Portuguese, including the instruction manuals and tutorials, and does not have system requirements that cannot be matched by the computers and internet connections available to teachers, either in their schools or homes.

The community is focused on biology teaching at the high school level. It is organized around 6 different forums: (1) news forum; (2) forum about evolution teaching; (3) forum about genetics and cell & molecular biology teaching; (4) forum about ecology teaching; (5) forum about botany teaching; (6) forum about general issues related to science teaching. It was planned to foster the construction of short-term action research projects for the teachers to implement in their own classrooms, in collaboration with the researchers. These projects were intended to arise, for the most part, from the teachers' concerns. Face-to-face meetings are occasionally carried out, in order to discuss how the community is functioning, the planning of action research, the analysis of data gathered during the classroom research projects, or to present specific resources to the teachers, such as teaching sequences or materials, either produced by the community itself, or resulting from some meeting, journal or other source.

METHODS

The investigation was qualitative in nature, amounting to a case study about the use of CoPs as tools for teachers' professional development and for diminishing the research-pratice gap. That is, our main research questions are: Is ComPratica functioning as a community of practice, as defined in the literature? If this is the case, is it possible to find clues that it is an effective tool for teachers´ professional development?

ANALYSIS OF THE COMMUNITY'S DYNAMICS

We obtained reports about the date of entrance and the whole set of actions of each participant of the community by means of a tool included in the platform Moodle™ itself. These data were collected at April 10th 2009, i.e., after one and a half year of existence of ComPratica. We could not gather reliable reports for the subsequent months, due to a problem in the storage of the data in the Moodle™ platform. With the available data, however, we were able to produce a consistent picture of the community's dynamics. It was possible to obtain data about the increase in the number of participants throughout the months until February 2010. We also obtained from Moodle™ reports for each of the forums included in ComPratica, in order to examine the distribution of participation and messages among them, also identifying which participants initiated threads of discussion with more than one message in all of the community's forums (with the exception of the news forum). To obtain data about the messages sent in the forums and chats, we retrieved all the messages, building a database with all the written information in the community.

Thematic analysis of the forum messages

We used two main approaches to characterize the messages sent in ComPratica forums, examining them in terms of both their content and the nature of the activities performed by the members. Here, we will only present a thematic analysis of the messages, carried out from February 25th to March 1st 2010. We obtained categories through an inductive process while analyzing these messages. A message could be classified in a single or in several categories.

RESULTS AND DISCUSSION

The dynamics of the community

ComPratica was initiated at November 27th 2007. In February 2010, the community was composed by 87 members. In Figure 1, we can see the dynamics of the community in terms of the number of participants throughout time. The pattern of growth observed in the community after two years of existence is a sign of its health and evolution.

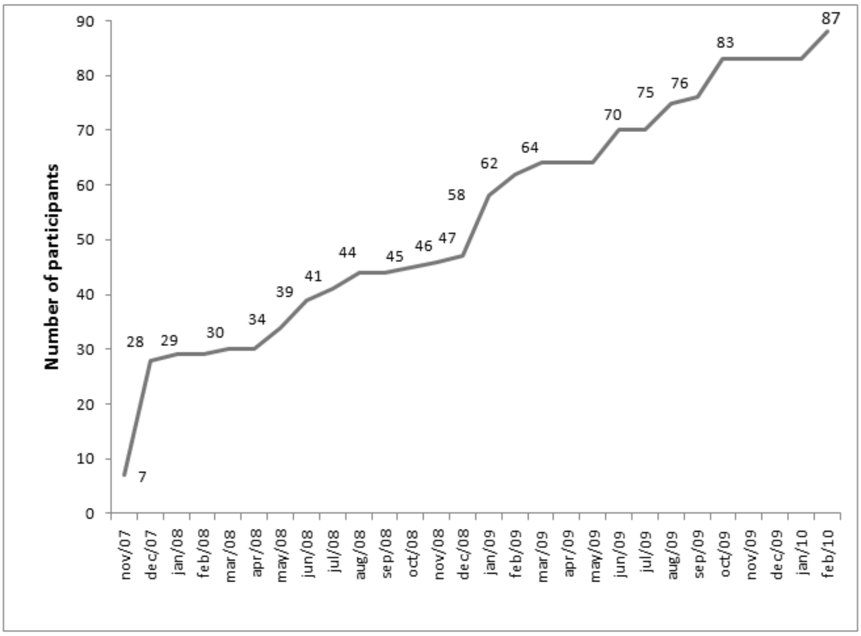

Figure 1: The dynamics of ComPratica in terms of the number of members throughout time (data from Feb 18th 2010).

Among the 87 current members, we find 32 high school in-service biology teachers (four of them also graduate students), 13 preservice biology teachers, 18 university teachers (ten also graduate students), 11 graduate students who are currently not involved in teaching, 9 undergraduate students, and 4 members who are engaged in other activities. The presence of a population with diverse interests and backgrounds is another indicator of the health of a CoP (Schlager et al. 2002) that is fulfilled by ComPratica.

Figure 2 shows the distribution of participation among the members until April 10th 2009, considering how many months have passed since their entrance in the community. We can immediately perceive a huge variation in the degree of participation among the members. Five members (7.8%) show the greatest number of actions in the community, ranging from 998 to 2101 records, including all kinds of action, not only writing messages. Three of them are high school teachers (VAP, ACS, DFA) and one is a preservice teacher (MAL). This suggests that the CoP is stimulating a significant engagement of at least part of the teachers.

While these three in-service teachers are quite active participants, writing many messages both in forums and chats, initiating threads of discussions, proposing topics for the chats, and engaging in the construction of teaching sequences for classroom action research, the pre-service teacher illustrates a silent manner of participation. We do not see her writing many messages or explicitly engaging in many activities. Nevertheless, by checking the records of her participation, we discover that she is constantly accessing the community, reading through most of the sent messages. It is important to notice, however, that the available data highly underestimates this silent participation, since all members receive the forum messages in their personal mailboxes, and, thus, can be participating silently without ever entering the community. In these cases, we can have no record of this participation. We need to use, thus, other means of assessing silent participation in the community.

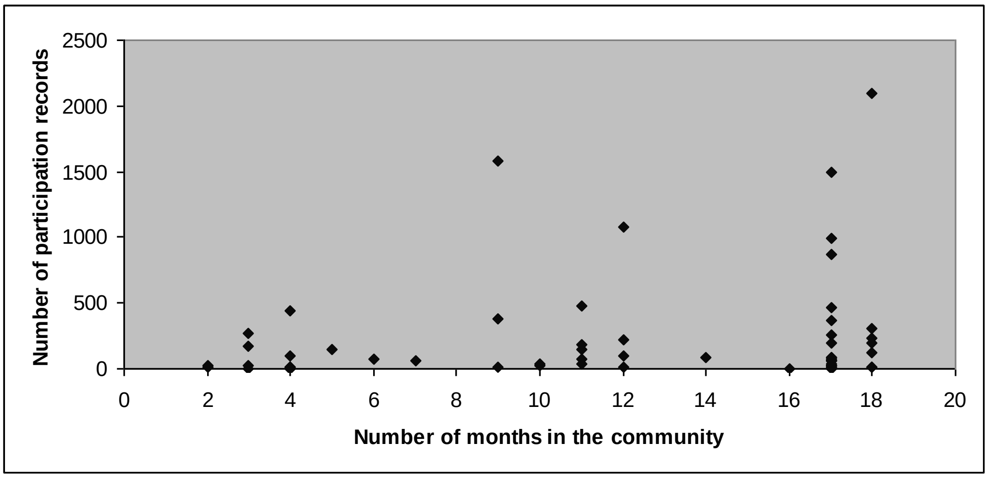

Figure 2: Participation of the members in ComPratica, in relation to the number of months since their entrance. Data from April 10th 2009.

There is a second group of members (20, 31.25%) who are often participating in the community through Moodle™, but does not reach values of recorded actions as high as the most active members (Figure 2). Anyway, this is also a quite significant participation, ranging from 92 to 869 recorded actions. Since many of these participants are in-service and pre-service teachers, their level of engagement provide further support to the conclusion that the community is really contributing to teachers' professional development.

Figure 3 shows the distribution of participation in the community until April 10th 2009 in a manner that considers silent participation with greater precision, since it takes into account the members' involvement with activities playing a central role in ComPratica. In the figure, members are distributed in circles according to their levels of participation, as indicated by recorded actions in Moodle™. Taking only these data into account, we find the five members with the highest degree of participation (7.8%) and 20 members with intermediate levels of engagement (31.2%). If we consider other activities that show an effective engagement of the members, as a way of including silent participation in our appraisal, such as (1) engagement in the construction, implementation, and testing of teaching sequences (MDG, CMU, CS, CF, CP, VRE, LCO, LCC, IS); (2) frequent initiation of threads of discussion (CS, MIB, LCO, LCC, IS); (3) involvement in the maintenance of the community (IG), we reach the figure of 16 members (25%) with a strong engagement in ComPratica. This inclusion appears as arrows in Figure 3, which show participants who move to the center of the community if we analyze other data besides the recorded actions.

If we consider that 25% of the ComPratica members showed, in the data gathered in April 2009, significant levels of participation, with no indication that participation has been diminishing in the last months, we will be able to conclude that the community has been and is very active. Indeed, it shows levels of participation that are much greater than those typically observed in virtual communities, where 90% of the users are generally lurkers, 9% contribute only intermittently, and a small minority (ca. 1%) answer for a disproportionately large amount of content and other activities (Nielsen 2006). Nielsen suggests the following distribution as being more equitable: 80% of lurkers, 16% of members contributing with some material, and 4% answering for most of it. In ComPratica, we observed until April 2009 an even better distribution of participation, with 5 (7.8%) members contribution with a greater amount of material and 20 (31.2%) also giving an important contribution to the community's dynamics (Figures 2 and 3).

We can describe this silent participation observed in ComPratica as a legitimate peripheral participation (Lave and Wenger 1991). This kind of participation is characteristic of communities of practice and plays an important role in professional and personal development. It can be conceived as a process of social learning in which participants gradually engage in exchanges and practices, moving from a more peripheral position to an increasing central place in the community. We observed this movement several times in ComPratica, particularly in the case of teachers who engaged more and more in classroom action research, even though they began (and some of them remained) without writing much in the community.

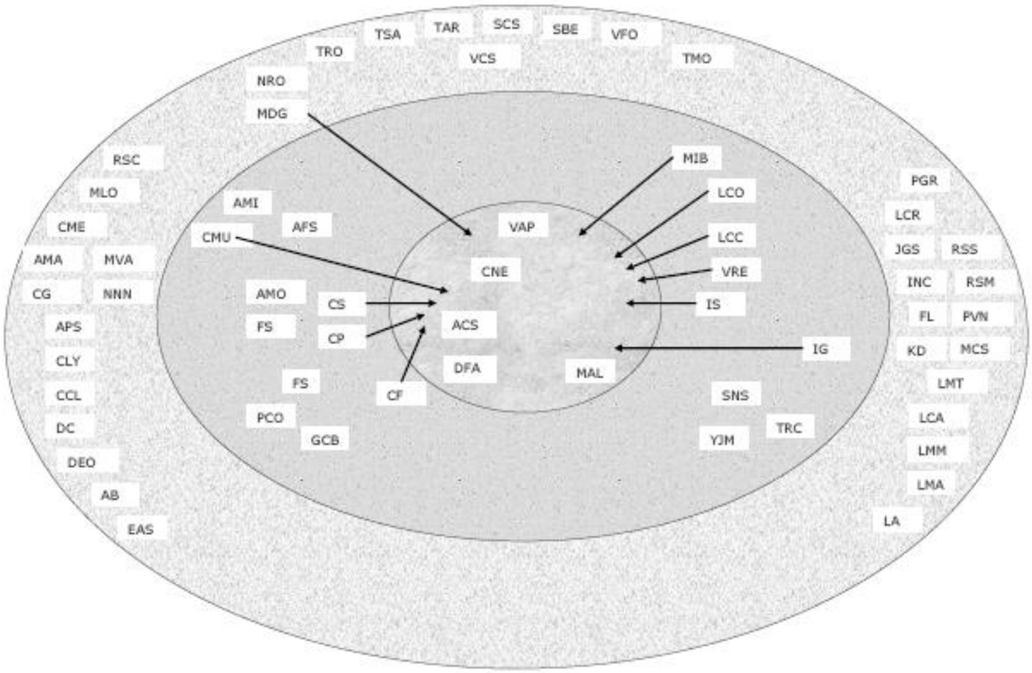

Figure 3: Diagram showing the levels of participation of members in ComPratica. Each member is represented by an acronym containing two or three letters. The outer circle includes members ranging from 5 to 90 recorded actions in the community. The intermediate circle shows members ranging from 91 to 990 actions. In the inner circle, we show members with more than 990 actions. The arrows indicate members with a level of participation which is higher than that indicated by the number of recorded actions in Moodle™. The criteria to identify these members are discussed in the text. Data from April 10th 2009.

All in all, a total of 893 messages had been sent to ComPratica until February 21st 2010 (on average, ca. 32 messages/month). Figure 4 shows the distribution of messages written in the community's forums (with the exception of the news forum) per members. One of the participants wrote much more messages than the other (CNE, 294 messages) due to the fact that he is one of the researchers in the group responsible for running the community and, in particular, for the task of stimulating participation, which is a key element in a CoP (Wenger, 1998). The members who sent more messages after CNE are, however, all high school in-service teachers (ACS, 82 messages; MIB, 70; DFA, 61; VAP, 57; IS, 52). This shows once again that the level of engagement of the teachers in the community is quite significant. A pre-service teacher also sent a considerable number of messages to ComPratica (CP, 24 messages). The same is true of two graduate students affiliated to the research group, who are also university teachers (CS, 42 messages; GCB, 37). Additionally, we should consider that 44 members (50.58%) of the community sent messages to the forums, which is yet another indication of their engagement.

Another data type showing this engagement concerns the initiation of threads of discussion by members of the community, considering only threads that indeed resulted in subsequent discussion (Figure 5). Once again, the fact that CNE initiated 25 threads of discussion follows from the particular role he plays in ComPratica. What is more interesting, thus, is the fact that high school teachers, such as ACS (11 initiations), IS (4), MIB and CMU (3), had provoked discussions throughout the existence of the community. Furthermore, the graduate students/university teachers GCB (6), CS (5) and LCC (3) also played an important role in stimulating discussions. All in all, 18 members (ca. 20% of the community) initiated threads of discussion, including 11 high school teachers, 2 preservice teachers, 4 graduate students (3 also university professors) and 1 university professor. These data add, in sum, to the evidence of substantial engagement of the teachers in the community.

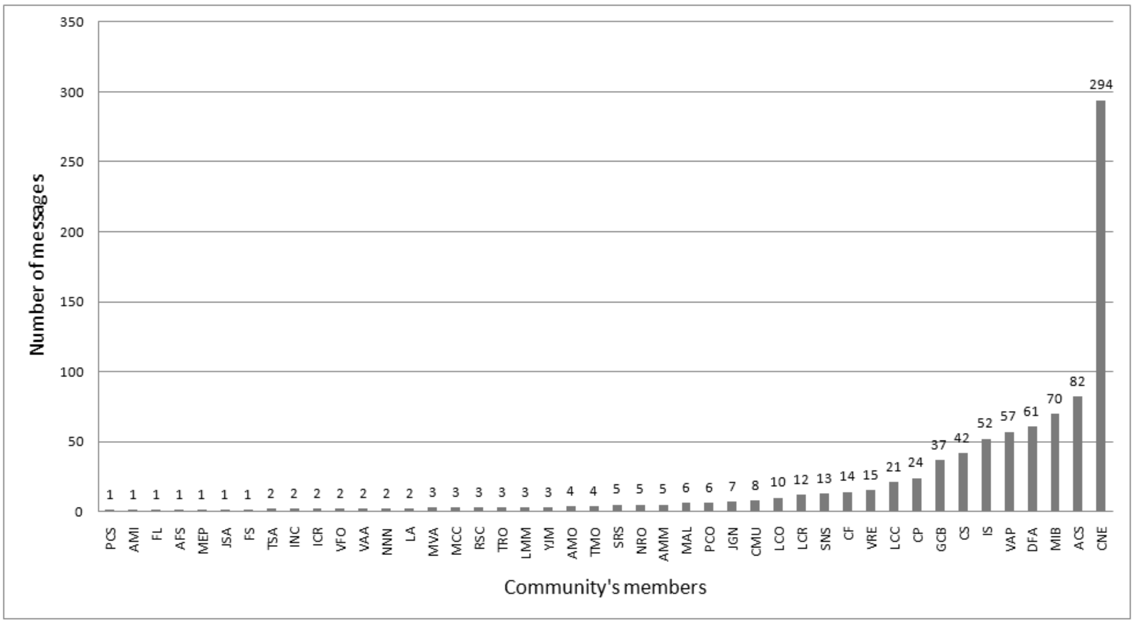

Figure 4: Distribution of messages written by the community's members in ComPratica forums, with the exception of the news forum. Data from February 21st 2010.

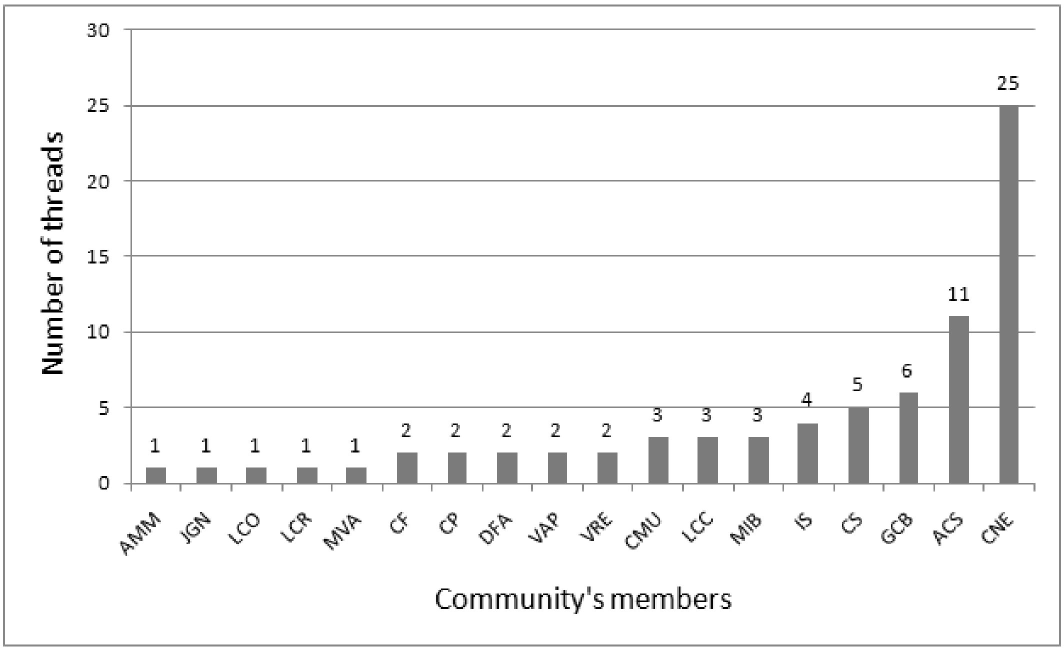

Figure 5: Initiation of threads of discussion by the community's members in ComPratica forums, with the exception of the news forum. Data from February 21st 2010.

Figure 6 shows the distribution of messages per forum in ComPratica. We can see that the forums that attracted most of the attention of the members were those related to general issues about science teaching (497 messages, 54%) and to evolution teaching (251 messages, 27.3%). Significant levels of participation are also seen in the case of the forum on genetics and cell & molecular biology teaching (124 messages/13.5%). The forum on ecology teaching shows a relatively limited number of messages (39, 4.2%). Finally, the forum on botany education has included until now only 9 messages (1%). We consider that there is a lack of interest in this forum, since the small number of messages cannot be merely explained by the fact that it is much more recent than the other forums. After all, in 10 months of existence, less than 1 message/month has been sent to this forum.

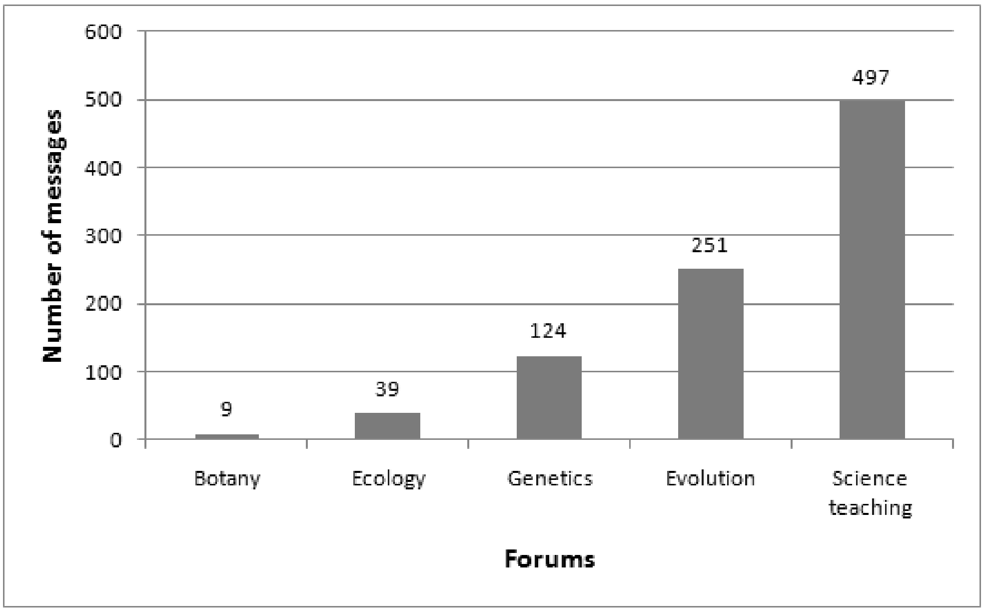

Figure 6: Distribution of messages in the ComPratica forums. Data from February 24th 2010. The total number of messages (920) differs from that shown in Figure 4 due to the interval of three days between the gathering of the data.

Thematic analysis of the forum messages

Figure 9 shows the distribution of messages sent to the forums of ComPratica (with the exception of the news forum). A total of 933 messages were analyzed. The discussion of the teaching sequences developed in the community was responsible for the largest number of messages (247, 26.47%). This is an important finding, since it shows that the community is indeed focused on one of its major goals, the construction of classroom action research about teaching sequences and instructional materials. As planned, action research has been playing a central role in ComPratica, providing us with opportunities of moving along the continuum between practitioner knowledge and academic knowledge portrayed by McIntyre (2005), so as to diminish the research-practice gap. Even though teaching sequences and pedagogical resources constructed outside the community are also discussed, most of the messages were devoted to the discussion of the teaching sequences collaboratively built inside it.

Educational themes were discussed in 178 messages (19.08%), including topics such as the current reform of high school in Brazil, the inclusion of special needs students in the science classroom, problems found in science textbooks, the paucity of the historical treatment of science contents in classrooms and textbooks, and the organization of science curricula.

Many messages (154, 16.51%) were devoted to the dissemination and discussion of texts and media programs, offering a significant contribution to its members' professional development and construction of teaching practices. This contribution also came from messages about internet resources (41, 4.39%), and courses and meetings (14, 1.5%).

The functioning of the community also deserved a lot of attention of its members (153 messages, 16.4%). Many of these messages were related to the organization of activities such as face-to-face meetings and chats. The most interesting of them, however, were those in which members proposed new kinds of activities to be carried out in ComPratica. This was the case, for instance, of a graduate student/university teacher who proposed that the community might have a specific locus for the members to upload texts reporting their classroom experiences or research results.

Among the educational issues discussed in ComPratica, we stressed teacher education and challenges of teaching biology or science, due to their central importance in the proposal of professional development underlying the community. Challenges faced by teachers in basic education were the topic of 115 messages (12.33%), while teacher education was addressed in 80 messages (8.57%). These discussions deserve attention because of the frequent occurrence of reports of the teachers' feelings in the face of the difficulties faced in teaching, which often led to reflections about the quality of their preservice education. This was particularly important to the beginning teachers in transition to practice, who often appealed to the experienced teachers in the community, as well as to the teacher educators, in search of advice about their first experiences as teachers. That's why we regard the discussions about the transition to practice highly important, even though they were the topic of only 31 messages (3.32%).

Conceptual issues were discussed in 97 messages (10.4%), mainly as a consequence of questions posed by the high school teachers. The depth and range of the concepts they wished to discuss were a bit surprising to us. In its two years of functioning, we saw in ComPratica conversations about issues such as the role of evolutionary thought in biology, the nature of learning in the science classroom, the role of tinkering (in opposition to design) in evolution, the relationships between science and religion, and the nature of the scientific methods.

Finally, the research-practice gap and role of communities of practice in bridging it also received some attention in the community (23 messages, 2.47%), in a kind of self-reflective loop.

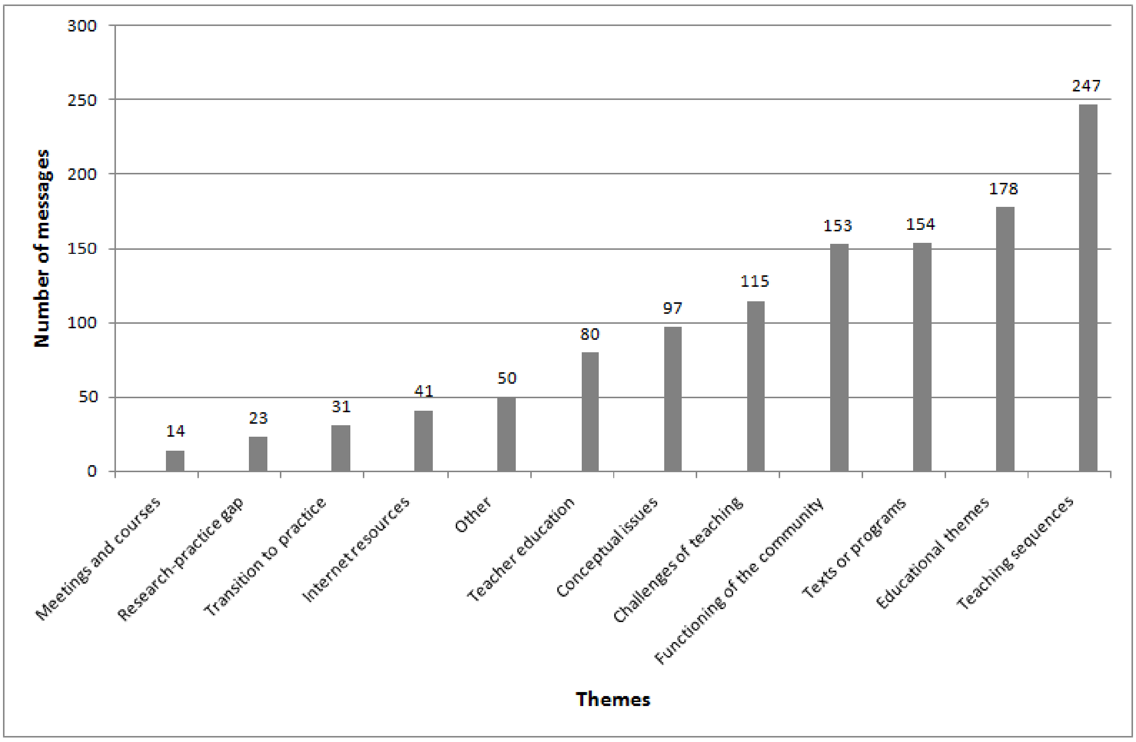

Figure 7: Distribution of messages sent to the ComPratica forums per theme. The categories of themes are explained in the body of the text. Data gathered February 25th to March 1st 2010. The number exceeds that shown in Figures 4 and 6 because this analysis was performed more recently.

CONCLUDING REMARKS

Our goal in investigating ComPratica was to find a way of bridging the research-practice gap. After two years of operation, we can say that this CoP is being effective in making the educational research we carry out much closer to teacher practice. A collaborative atmosphere has been built within it, with high levels of participation and engagement, and the construction of praxis in the form of classroom action research. ComPratica is making room for the integration of a relevant parcel of actors involved in teacher education, educational research, and pedagogical practice, contributing to the improvement of science teaching, the education of future teachers and teachers' professional development, alongside with building a greater proximity between research and practice. The results obtained in the first two years of ComPratica lead us the conclusion that it is growing up to be not only a "community of learners", but, above all, a "community that learns".

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BIOLOGY STUDENT TEACHERS AS TARGETS AND AGENTS OF CHANGE

Doris Elster

University Bremen / Institute of Biology Education

Doris.Elster@uni-bremen.de

ABSTRACT

BIOKOMP (Competency-Oriented Teaching and Learning of Biology) is an Austrian project to facilitate the implementation of national educational standards. This requires Austrian schools to transition from the input orientation typical of science education to an outcome orientation. Are teachers prepared for this change? What is the impact of a university education on student teachers' attitudes towards competency-oriented teaching and learning? To investigate these key questions, a questionnaire survey was conducted at the University of Vienna in 2009. A total of 360 biology student teachers (223 beginners, 147 advanced) participated in the survey (quasi-experimental design; factor analysis). Additionally, qualitative data of a new model of school-university cooperation (the BIOKOMP Practical Course; 30 students, 6 teachers; action research) were analyzed. The main findings of the questionnaire survey are as follows: (i) students can be classified as subject-conventional (38%), subject-innovative (11%), method-innovative (26%), or pupil-oriented (25%); (ii) these classifications are based on seven factors that influence attitudes towards fostering competencies; (iii) there is an increase in subject knowledge from beginners to advanced students; (iv) however, only participants of the BIOKOMP Practical Course show a significant increase in epistemological knowledge and skills. To sum up: There is a need for new models of school-university cooperation through which teachers and teachers students work together to promote and foster educational reforms.

Keywords: *pre-service education, competencies, personality traits, national educational standards, educational reform.*

BACKGROUND AND THEORETICAL FRAME

Promotion of competencies in biology education

The disappointing results of the Third International Mathematics and Science Study (TIMSS) and PISA have given rise to a shift in the Austrian educational system, from the input orientation typical of science education to an outcome orientation. Many pupils are unable to apply the knowledge they acquire in school to the solution of complex problems, fail to work on an experimental basis, or fail to argue from the point of view of science (Baumert et al. 2001). These shortcomings of biology education show that the many competencies regarded as vital for participation in modern, knowledge-based society are insufficiently promoted (Bayrhuber et al. 2006).

In Austria the discussion of competencies is connected to the development of National Educational Standards (Lucyskyn 2006). Based on the concept of scientific literacy (KMK 2004), National Education Standards aim to enable students to actively participate in societal communication and to form opinions concerning technological developments and scientific research. A further goal is the development of scientific thinking and working, as well as the critical discussion of the limitations of scientific methods. In summary, the National Educational Standards define four competency areas: subject knowledge, epistemological skills and knowledge, subject-related communication, and decision making and judgment (see Table 1).

Teaching in this standardized framework requires new practices and a re-orientation of instruction from a traditional input orientation to an outcome-oriented approach. As shown by Terhart (2002), increasing attention must be paid to the development of teachers' competencies. Are teachers and student teachers prepared and willing to implement competency-oriented teaching? What is the impact of a university education in this school-based reform process?

Table 1. Competency areas and examples of standards.

Subject knowledge	▪ Understand biological phenomena, concepts, principles, facts. ▪ Convey basic biological facts and concepts, as well as impart complex knowledge, rather than relate details of the subject matter. ▪ Lay the foundation for cumulative learning by connecting biological concepts to concepts in other areas of science, and make these concepts applicable through both horizontal and vertical networking.
Epistemological skills and knowledge	▪ Utilize experiments and other inquiry methods, such as criteria-based monitoring and comparison and models. ▪ Foster an understanding of scientific thought on the working methods applied in biology.
Subject-related communication	▪ Collect and exchange subject-related information and reflect upon norms and values. ▪ Previous knowledge, notions held by pupils, and the learners' level of expertise are of crucial importance.
Decision making and moral judgment	▪ Recognize and assess biological facts on the basis of models of ethical reflection and discern descriptive and normative aspects. ▪ Systematically relate subject knowledge to relevant norms and values so as to arrive at a substantiated conclusion.

Founded by the Austrian Foundation of Research (FWF), the four-year project BIOKOMP (Competency-Oriented Teaching and Learning of Biology) aims to facilitate the development and implementation of standards (Elster 2010) at the levels of pre-service and in-service education.

In the first stage of the project, teachers and student teachers build learning communities (Lave & Wenger 1991; Elster 2009) to plan competency-oriented materials and units. These materials are tested in the classroom. Later, they reflect on classroom experiences and discuss pupils' competencies. In the second stage of the project, competency-diagnostic units are offered via the Internet to establish a blended learning scenario.

On the development of teachers' professionalism in learning communities

The discussion of competency orientation in biology education is strongly connected with a discussion of teachers' professional development. It is assumed that reflection and networking are the keys to promoting change and should underpin school-based reforms (Elster 2009; Elster 2010).

According to theories on teachers' professional biographies (Terhart 2001), occupational development is largely based on a teacher's subjectively experienced and digested teaching practice. Consequently, accumulation of practical knowledge and helpful routines in a teacher's behavior will not be affected by general theoretical insight and developments–i.e., a teacher's behavior runs the risk of remaining subjectively isolated. Hence, there is a need to provide support systems to enable teachers to link subjective experience with theory.

The BIOKOMP project will provide support on a different level. It is assumed that continuing professional development programs are most effective if they include central aspects of professional practice that offer participants the opportunity for "situated learning" (Lave & Wenger 1991). This is ensured by the concept of professional development in learning communities, based on the theory defined by Brown (1997). According to Brown, the experience gained by teachers—in cooperation with student teachers—as a result of their teaching practice can be linked with teaching theories to trigger educational reform processes. Although in the short run this will entail practical modifications of the current teaching practice, in the long run a continuing professional development is anticipated.

Learning communities involving both teachers (student teachers) and researchers of science education provide the settings for the conceptual development of instruction. Teachers implement the plans in the classroom. In subsequent meetings the members of the learning community reflect on the gained experiences in order to facilitate the development of both the concepts and the school's teaching practices. Both the planning processes and reports of results will be accompanied by the teachers' and professionals' reflections to help the teacher develop into a critical and reflecting practitioner (Schön 1987).

It is one of the goals of the BIOKOMP project to integrate biology student teachers into learning communities of teachers and researchers. This is done in the framework of an innovative lecture, the BIOKOMP Practical Course.

The BIOKOMP Practical Course—an innovative model of teacher education

Traditionally, Vienna University's teacher training program is not much different from the curriculum for its biologist training program. Only recently has it become possible to design courses that are specifically addressed to future teachers and that create at least some links between theoretical coursework and teaching practice in a school context. One of the first innovative courses of this kind is the BIOKOMP Practical Course, a new model of university lectures in which student teachers and teachers work in teams to cooperate in the development of competency-oriented teaching materials and units.

BIOKOMP teams one in-career teacher with four to six student teachers. First, they determine the previous knowledge and possible questions of pupils in the second to sixth form (ages 12 to 16) in the school in which they are about to teach. Second, they plan teaching sequences on their topic (e.g., fostering epistemological knowledge and skills using experiments with living animals). On one hand, the teaching sequences offer basic subject knowledge; on the other, they allow pupils to do experiments and to take responsibility for their work as much as possible. For this purpose, the team designs several "stations" at which small groups of pupils can plan, conduct, analyze, and reflect on experiments, assisted by a student teacher.

Another important part of the course is the pupils' reflection on their approaches and on their processes of knowledge acquisition and competency development. The student teachers document their experiences and the findings of the competency diagnostics in a portfolio. These portfolios form the basis of the project reports towards the end of the course.

The teachers of the classes in which the student teachers have their practical experiences introduce the student teachers to the class and show them their facilities and equipment. They do not intervene in the process but rather reflect, together with the student teachers, on the classroom experiences and pupils' competency development.

Is the BIOKOMP Practical Course successful in promoting student teachers' willingness to foster competency-oriented teaching and learning? Are there differences between the participants of the BIOKOMP Practical Course and students who do not participate in the BIOKOMP lectures?

The personality approach in biology teacher typology

Compared to the overall population, biology teachers and student teachers represent a relatively homogenous group. However, differences in professional practices have been identified, especially in regard to readiness to implement new teaching concepts (Neuhaus & Vogt 2005). Whether and in what way personality traits (according to the Five-Factor Model by McCrae & Costa, 1999) have an impact on the attitudes of biology student teachers have not yet been established on an empirical basis.

Against the theoretical background outlined above, this study intends to establish empirically founded types of student teachers (Kluge 1999). This classification will be made in accordance with (i) their personality traits ("Big Five"); (ii) their professional self-concept and attitudes towards teaching and learning (Neuhaus & Vogt 2005); and (iii) their general attitudes towards teaching and the promotion of the following competency areas: subject knowledge, epistemological skills and knowledge, subject-related communication, and decision making and judgment (Elster 2007; Lücken 2006). These characteristics will be related to (iv) the duration of university education (beginners or advanced students) and (v) participation in the BIOKOMP Practical Course.

There are three core research questions:

(1) Do biology student teachers differ from each other in respect to (i) their general attitudes towards teaching and learning, (ii) their attitudes towards fostering competency areas, (iii) their epistemological skills and knowledge, and (iv) their personality traits?
(2) Are there differences between beginners and advanced students?
(3) Are there differences between participants of the BIOKOMP Practical Course and non-participants?

RESEARCH DESIGN

A multifaceted research approach

To investigate the research questions, the author uses questionnaires in a quasi-experimental design (beginner and advanced student teachers) to analyze the student teachers' attitudes towards promoting competency-oriented teaching and learning and to analyze their epistemological knowledge and skills.

Additionally, an action research approach (Altrichter & Posch 1998) is used as a tool for professional development as well as for measuring and analyzing professional development within the BIOKOMP Practical Course.

Action research is expected to support teachers (or student teachers) in establishing a research relationship with their own practice. It should increase their professional knowledge, enhance the effectiveness of teaching and learning, and broaden their autonomous scope. It should empower teachers as "reflective practitioners" to develop their "tacit knowledge" (knowledge in action) through "reflection on action" (Schön 1983). It is assumed that various premises can be made transparent in a value-neutral way by "mirroring" practice. This can facilitate reciprocal learning processes.

Methods, participants, data source

Questionnaire survey. From October 2008 to January 2009, 360 student teachers at the University of Vienna were asked to complete an anonymous questionnaire.

Description of the participants: 81% female, 19% male; 223 beginners, 147 advanced students; age between 19 and 45.

Description of the questionnaire: 126 items in 6 sections:

- *Attitudes towards teaching and learning* (22 items; 4-point Likert scales; based on Neuhaus & Vogt, 2005)
- *Attitudes towards fostering competency orientation* (20 items, 4-point Likert scales; based on Elster 2007; Lücken, 2006)
- *Personality traits* (22 items, 5-point Likert scales; based on McCrae & Costa 1999)
- *Own experiences* with biology as a school subject (27 items, 4-point Likert scales)
- *Epistemological skills:* analysis of two experiments and development of one experiment (open questions)
- *Demographics* (age, gender, years of university education, subsidiary subjects)

The data were analyzed in SPSS using descriptive and factor analysis, as well as means, t-test, ANOVA, factor and regression analyses.

Portfolios. Additionally, in 2008 and 2009, two BIOKOMP practical courses were conducted.

Description of the participants: 30 biology student teachers (90% female, 10% male; all advanced students; age between 22 and 27) and 6 biology teachers (5 female, 1 male; age between 45 and 53).

Data sources: 30 student teacher portfolios with the following contents:

- Description of school and participating teacher (including interview transcript)
- Investigation of pupils' preconceptions, knowledge, and interest (e.g., regarding experimentation with living animals)
- Planning and testing a competency-oriented teaching sequence
- Reflection on class experiences, competency diagnostic, and teamwork

FINDINGS AND ANALYSIS

Based on the data gathered from the questionnaire survey (N = 360), the following results can be reported:

Biology teacher student profiles

Attitudes towards teaching and learning

Regarding student teachers' teaching and learning approaches, four subscales can be identified (explorative factor analysis; four factors [value>1] explain 63.12% of the variance). Based on these subscales, four student teacher profiles can be defined (see Table 2):

subject-conventional profile (38% of the student teachers)

subject-innovative profile (11% of the student teachers)

methods-innovative profile (26% of the student teachers)

pupil-oriented profile (25% of the student teachers)

Table 2. Attitudes towards teaching and learning

Subscales	Number of items	Exemplary item	Realiabilty Cronbach's *α*
Subject-conventional profile	n = 6	The biology teacher should be a subject expert.	α = 0.76
Subject-innovative profile	n = 6	It is important that the biology teacher integrate current research themes into the lessons.	α = 0.86
Methods-innovative profile	n = 5	The biology teacher should be open to innovative methods.	α = 0.72
Pupil-oriented profile	n = 3	The biology teacher should teach themes in a socio-scientific context.	α = 0.61

Attitudes towards fostering competencies

As a result of the factor analysis, the author identified seven subscales (explorative factor analysis; seven factors explain 81% of the variance). The subscales, number of items, and reliabilty are reported in Table 3.

Table 3 Attitudes towards fostering competencies

Subscales	Number of items	Exemplary item	Realiabilty Cronbach's *α*
Subject knowledge	n = 5	In my biology lessons, pupils shall learn domain-specific knowledge (e.g., evolution).	α = 0.77
Theoretical experimental skills	n = 3	I want to instruct my pupils in scientific thinking and scientific methods.	α = 0.73
Practical experimental skills	n = 3	The pupils will learn how to plan, perform, and analyze an experiment.	α = 0.82
Subject-related communication	n = 4	The pupils will be able to interpretate biological diagrams.	α = 0.60
Ethical judgement	n = 3	The pupils will learn to argue scientifically in bioethical discussions.	α = 0.75
System thinking	n = 2	It is necessary to foster interdisciplinary thinking.	α = 0.45
Judgment in the context of sustainability	n = 3	It is important that the pupils learn to accept the environment as something protectable.	α = 0.71

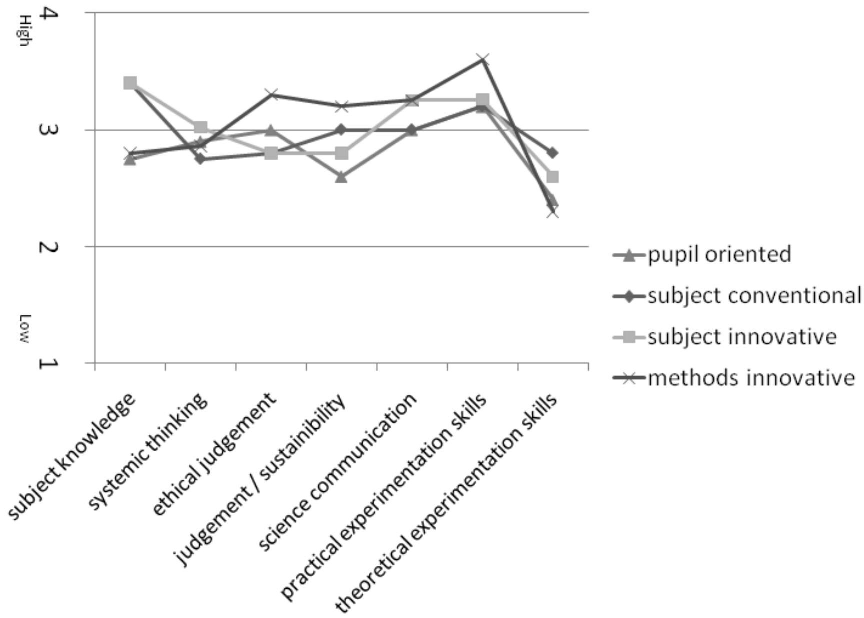

Figure 1. Correlation between student teacher profiles and attitudes towards fostering competencies (N = 360; 4-point Likert scales; 1 = I totally disagree, 4 = I totally agree)

Figure 1 illustrates the correlation between student teacher profiles and attitudes towards fostering competencies. The intention to foster competencies is generally high (4-point Likert scale; means 2.5). Differences exist on the scales of subject knowledge (subject-conventional profile and subject-innovative profile > pupil-oriented profile and methods-innovative profile), ethical judgment, and judgment in the context of sustainability (methods-innovative profile > other profiles). Fostering practical experimental skills is more important than fostering theoretical experimentation skills (e.g., planning or analyzing an experiment).

Correlation between personality traits and gender

In regard to the Five-Factor Model of McCrae & Costa (1999), the five subscales ("openness to innovations," "compatibility and cooperation with others," "conscientisness," "neuroticism," and "extraversion") can be confirmed by factor analysis (five factors [value>1] explain 81% of the variance). Figure 2 shows the distribution of these five factors between male and female students. Significant differences exist only on the scales "neuroticism" (t-test; $p<0.01$) and "conscientiousness" (t-test; $p>0.001$). There is no significant difference between beginners and advanced students or among the four different student teacher profiles.

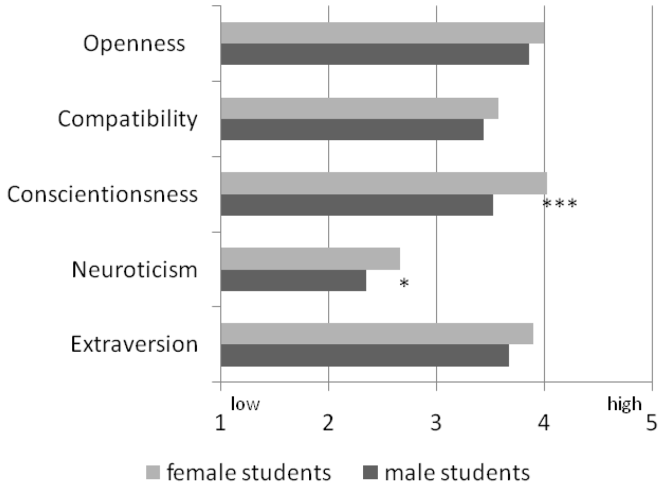

Figure 2: Comparison of personality traits of male (n = 72) and female (n = 288) students. 5-Point Likert Scales. 1 = I totally disagree, 5 = I totally agree. *** $p<0.001$; ** $p<0.01$

Beginners and advanced students

Correlation between epistemological skills of beginners and advanced students

Only 39% of the participating students could identify mistakes in the conduct of experiments. The scores (0-1) of pupils' answers ranged from 0.575 (min) to 0.975 (max). The average score was 0.92. There was no significant difference between beginners (0.90; SD 1.02) and advanced students (0.92; SD 0.82). The author assumed that the student teachers' ability to assess classroom experiments and their epistemological skills could be more developed.

Correlation between beginners' attitudes and advanced students' attitudes towards fostering competencies

It is important for beginners as well as advanced students to foster subject knowledge (see Figure 3). Fostering subject-related communication and ethical judgment is of less importance. In regard to knowledge acquisition, there are differences between "theoretical" (e.g., to think over how to perform criteria-based comparision of plants) and "practical" (e.g., to plan, perform, and analyze an experiment). The results show that there is a significant increase in the attitudes towards fostering theoretical experimental skills ($p>0.01$), systemic thinking ($p>0.001$), and subject knowledge ($p>0.001$) from beginners to advanced students.

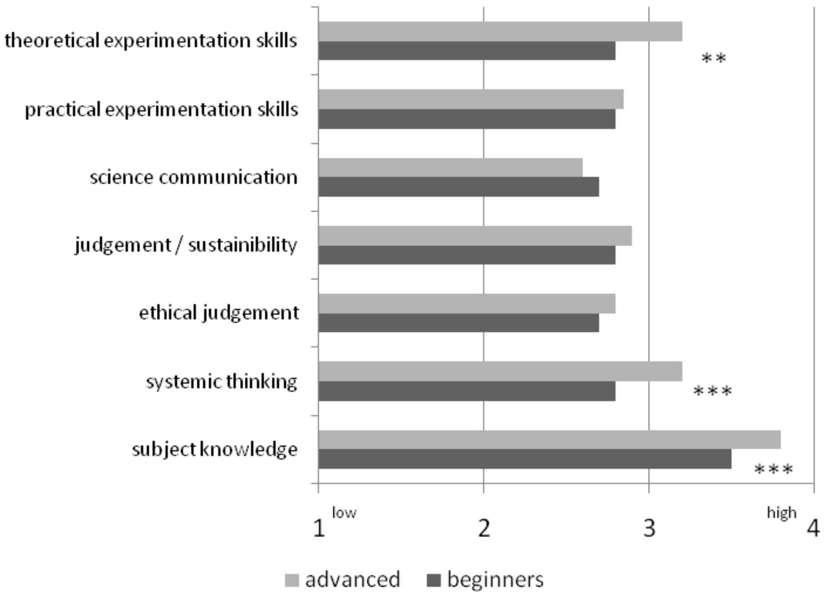

Figure 3. Comparison of attitudes of beginners (n = 223) and advanced students (n=147) regarding fostering competencies. 5-Point Likert Scales. 1 = I totally disagree, 4 = I totally agree. *** p<0.001; **p<0.01

Participants of the BIOKOMP Practical Course compared with non-participants

Based on the analysis of the portfolios of 30 student teachers, the main results can be summarized as follows:

(i) The epistemological knowledge and skills of the participants of the BIOKOMP Practical Course are higher than those of non-participants (participants > non-participants; see Figure 4).
(ii) There is a difference in the attitudes towards fostering subject knowledge (participants < non-participants).
(iii) There is no difference in the attitudes towards fostering ethical judgment or judgment in the context of sustainability.

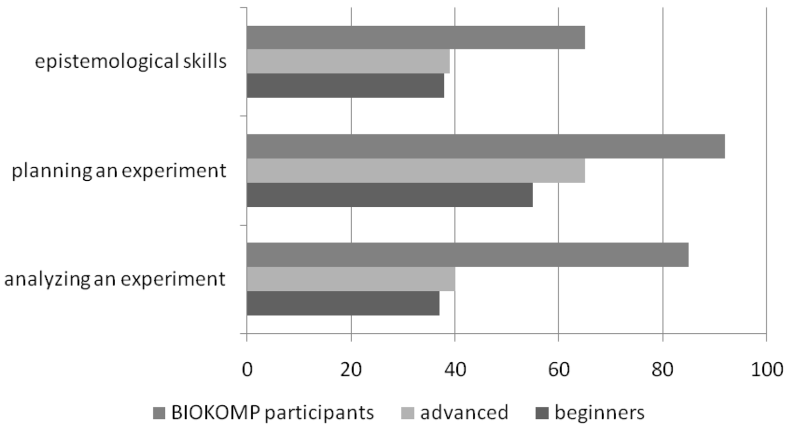

Figure 4. Epistemological knowledge and skills of BIOKOMP participants (n = 30), beginners (n = 223) and advanced students (n = 147). Scores in %.

CONCLUSIONS AND IMPLICATIONS

The initial findings of BIOKOMP allow the classification of students into four profiles. Whereas 49% of the participating students (N = 360) are subject-related (innovative or conventional), 51% are pedagogical-related (method-innovative or pupil-related). These profiles differ in regard to the student teachers' attitudes towards fostering seven competencies: subject knowledge, theoretical experimentation skills, practical experimentation skills, decision making and judgment in a bioethical context and the context of environmental education and sustainability, subject-related communication, and systemic thinking.

There is no correlation between student teacher profiles and personality traits, but there is a correlation between gender and the personality traits neuroticism and conscientiousness (female > male). Extraversion, mental stability, and conscientiousness are accompanied by commitment and openness in promoting competency orientation.

University education has little impact on the attitudes of the student teachers in regard to fostering competencies in the classroom. Significant differences exist only in the willingness to promote subject knowledge, systemic thinking, and theoretical experimentation skills (advanced > beginners); but fostering further competencies based on the standard framework is not reflected or promoted.

The participants of the BIOKOMP Practical Course show a high increase in experimental skills (planning and analyzing experiments) and in epistemological knowledge, whereas the knowledge of non-participants (beginner and advanced) is lower.

In summary, the BIOKOMP Practical Course is an effective tool for fostering competency, diagnostic and epistemological skills, and knowledge. The learning communities of teachers, student teachers, and researchers provide support for student teachers as they reflect on the change from input orientation to outcome orientation in teaching and learning. Student teachers (as well as ongoing teachers and in-career teachers) can be seen as both agents and targets in the implementation of National Educational Standards.

Further research needs to be conducted on how participation in BIOKOMP learning communities influences the concepts of teaching and learning and the professional development of in-career teachers.

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ARE THERE DIFFERENT TYPES OF PHYSIC TEACHERS? – ABOUT TEACHING SUSTAINABLE ENERGY IN AN UPPER SECONDARY SCHOOL PHYSICS COURSE

Susanne Engström

UKK, Mälardalen University

Västerås, Sweden

susanne.engstrom@mdh.se

Peter Gustafsson

UKK, Mälardalen University

Västerås, Sweden

peter.gustafsson@mdh.se

ABSTRACT

The declining interest for science and technology among pupils in the Western world is a threat against economical growth, the welfare system and also a democratic problem. A key person for a change is the teacher. We must therefore, as a start, identify what and how teachers in science teach. Results from a survey of physics teacher in Sweden who teach energy in the course Physics A in upper secondary school are presented. Through a questionnaire the teachers were asked what they choose to teach and what methods they use. We found that a majority of them focus on basic physics concepts, their relations and text book problems solving. Overall they teach in a traditional manner, without valuating content and without connecting to the environment, society or future technologies. From a cluster analysis of the answers three different groups of physics teachers were revealed. A large group named the Mainstream Group, a second group, the Future Solution Group, and a third Challenger Group. The latter consist of teachers who, in addition to basic concepts and relationships, also teach with a more valuating content, allowing sustainable development to characterize the content and use a variety of teaching methods and material.

Keywords: *Physics education, physics teacher, energy education.*

INTRODUCTION

Physics education should empower future citizens in a way that enables them to participate and contribute to debate about the role of physics in society and the issues surrounding physics (Cross & Ormiston-Smith, 1996, s. 656).

The Physics subject content in upper secondary school, have an aim for students to achieve understanding of sustainable energy, and consist of basic physics concepts and their relationship. These are exemplified not only in "limited contexts" (a notion that stands for an application, scientific phenomena or an example to which the basic concept can be linked) but also in broader contexts, such as the students own energy use and the energy flows through society and through nature. Within this broader context, it is necessary that problems, such as environmental problems and efficiency problems occur and that a discussion on future solutions is involved. An even distribution should be established between the physical concept, its context and "limited contexts" on one hand and the broader context, related problems and solutions on the other. In addition to the basic physics knowledge, and its connection with the limited contexts, such as certain natural phenomena and technical applications and a basic understanding of the energy flows through the society, students should be able to reflect on the economical and political decisions and values related to energy use (Engström, 2008a; 2008b). The students' own use of energy may be a starting point in that, to let students think about their own situation and compare it with the situation on other continents. The Swedish curriculum for physics (SKOLFS 2000:49) also states the objective that the student should be able to discuss ethical issues related to physics.

An even distribution of the subject content did not appear in physics textbooks or in *one* classroom study when analyzed (Engström, 2008a; 2008b). The results instead show that the emphases are on basic physics concepts, their relationship and large focus on calculation skills. This despite the fact that the curriculum stresses the need for students to obtain knowledge and understanding of energy issues in society and impacts on the environment from the use of energy. Such knowledge is made possible by relating the physics knowledge into context, for the students to 'think in systems', so they understand the processes and problems that the energy use causes, and that the human energy system causes changes in the natural cycles.

The present study is based on the results of an investigation by Engström (2008a, 2008b) on what constitute an appropriate subject content in a physics course in upper secondary school for students to understand and to be involved in society's energy issues, and to realize what sustainable energy stands for. In this article we describe results from a subsequent deeper and broader study of physics teachers - what *subject content* they teach and *how* they teach in terms of energy in the Physics course A (related to a subject content for sustainable energy use) in the Swedish upper secondary schools. Out from this we will present different types of physics teachers.

BACKGROUND

‘SOMETHING MORE’ - WHAT AND HOW IN PHYSICS TEACHING OF ENERGY

Engström (2008a, 2008b) emphasised the importance of reaching an understanding of the problems and solutions, not "only" an understanding of the context. SOU 2004:104 (Swedish official report from the government) mentions that it is not enough for people to obtain knowledge of the cause - effect - conditions that science has highlighted if we want individuals to understand how sustainable development can take place and if we as individuals will realize what we can do to contribute to sustainable development (Öhman, 2003). According to SOU 2004:104 education need to support students to both clarify the causal relationship in a field and point out what individuals can do to influence events in a sustainable direction.

Ideally, the subject content contributes to the students’ ability to realize the strategies that must be asserted in the future, for example requirements on future technologies and what wise choices that are important to make in a person’s lifestyle. Such subject content can be compared to Roberts (1982) "science, technology and decisions - emphases." It is important that students want to work for sustainable development locally and globally (Gayford, 1991; SOU 2004:104). It requires teaching strategies for a holistic approach, a Vision II (Roberts, 2007) where students receive science knowledge for citizenship.

The current Swedish curriculum (Lpf94) value-system, including physics teaching, emphasises a democracy perspective. Teaching should for example enable students to examine their own energy use in discussions, in calculations and in concrete issues. This has two purposes, first the personal experience provides a better understanding and second the students themselves will develop a commitment (Space, 2007), that they need to change attitude and behaviour (Gayford, 1991), that they receive an “action competence” (Öhman, 2003).

To receive “action competence” students have to be trained in detecting and solving problems, and trained to develop critical thinking and they must also gain insight into the natural cycles in order to understand what is happening in different systems (Hansson, 2000). Teaching may also very well contain investigative contexts in which students learn content and recognizing situations in which the content has a value (Barab & Luheman, 2003). Students may get a line of argument, so they can relate physics concepts to contexts, and that they within these arguments realizes that one can and must evaluate different aspects (Space, 2007). The *Reality-based* learning that education for sustainable development requires is very important but contacts with the local community are few and sparse in the school (Öhman, 2003). The student must get a chance to lives through *democracy* in education. To create knowledge means that one, according to Öhman (2003), builds a relation with the world. According to UN (2003) participatory and a holistic approach should imprint the education, students should be encouraged to critical thinking and reflection, education must be process-oriented and participant regimented.

DILEMMAS AND PROBLEMS FOR ’SOMETHING MORE’ IN PHYSICS TEACHINGS

A *dilemma* is that the physics subject has to make students transfer knowledge to another context and “something more”, while at the same time becoming one with the physics culture. To become involved in a knowledge culture is to think, act, talk in a certain way - to master the natural sciences. This culture of natural science is guided by its tradition and its approach (Schoultz et al., 2003; Andersson, 2003; Ingelstam, 2004) for example the importance of understanding a notion in a scientific way. But, as Andersson et al. (2003) argues, scientifically not acceptable perceptions can be part of a set of values which are important for an individual person and the individual's involvement and critical thinking and the school should promote a development in society (which requires that students receive a certain insight) which must give students the right to think freely and express their opinions (Öhman, 2003). A *problem*, exposed with experiences from the PLONE – project (with the intention of democracy in education by including students’ influence), is that it will became difficult for many science teachers accepting that their situation changed to a smaller proportion of lectures in whole class, and more to be a listening party who provides adequate feedback on students' own statements and briefings (Kortland, 2002).

A TRADITIONAL WAY OF TEACHING PHYSICS

The teacher studied in Engström (2008a, 2008b) has a major focus on helping students to succeed in calculations. The teaching is based on the physics textbook and the teacher has selected the appropriate section and allows students to do most of the calculations. Communication in the classroom consists mostly of one-way, the teacher is lecturing and the students are listening and taking notes. This method of teaching is reflecting a attitude consistent with several studies (Thomas, 1990; Tobias, 1990; Staberg, 1994; Benckert &

Staberg, 2001) giving that the subject of physics is a culture not easy to enter and not welcoming, especially for women and to alter traditional teaching is not easy but also not always welcome even among the students. The subject is regarded by the pupils as describing, not reflecting, and answering question never posed by them. Science is becoming a fossil for them (Sjøberg, 2005).

Physics is traditionally seen to be highly mathematical. “Physics teachers have a tacit understanding, strongly shared by the students, that the important aspects of physics have to do with manipulations of mathematical symbols” (de Souza & Elia, 1998, p. 3). In physics as academic subject a common approach is to preserve the contents, with a focus on traditional physics concepts, its scientifically correct definitions in order to understand the context (facts) and to perform calculations (Ingelstam, 2004; Gyberg, 2003)

PHYSICS TEACHERS VIEW AND CONSEQUENCES FOR SCHOOL PHYSICS

Physics teachers in secondary school have a more traditional view of science than elementary teachers. They mean for example that “the only valid way of gaining scientific knowledge was through the application of inductive methods based upon observation and controlled experimentations” (Pomeroy, 1993, p. 262). Teachers in secondary school have a more formal science training which can explain their “deep initiation into the norms of the scientific community” (Pomeroy, p. 269). Why secondary teacher have these values and beliefs can also depend on influences by years of exposures to the presentations of science by text books, an idealised model of science, or working for a long period in schools that value factual knowledge, schools “that often encourage control over creativity and reward teaching students fact auspices of educating them” (Brickhouse, 1989, p. 448).

Physics teachers’ practice teaching within the boundaries defined by very powerful socializing forces and due to Cross & Ormiston-Smith (1996) this has considerable consequences for teaching activities which do not overtly support these values. Some of the standard outcomes of the processes of socialisation of physics teachers are, very shortly: that physics deals with objective knowledge gained through formalized scientific methods, that physics is a difficult subject, that the content of physics is free from the influences of culture and gender, that the achievements of physics can be seen as an ever increasing understanding of nature and therefore power over nature, that the history of physics can be understood by projecting our present knowledge and understanding back in time, that in the minds of teachers the knowledge produced by physicists is placed at a higher order than other forms of knowledge, schooling of physics is likely to be the same wherever physics is taught depending on progress towards increased knowledge requires a systematic approach to knowledge acquisition – progress in physics requires progression via a universally syllabus (Cross & Ormiston-Smith, 1996).

Hansson (2000) argues that the traditional subject division in school makes issues relate to a subject to be locked into specific situations and approaches. The truth is written in the book, in the subject, and expressed by the physics teacher, a person who is perceived as clever because he demonstrates mastery of a subject that is difficult to tradition, a view which, among other, Berner (2004) highlights. It is likely that the scientific culture of objectivity is reflected in textbooks and in teaching. It can be a resistance to evaluate and emotionally take a position on various issues. Gyberg (2003) shows how physics do not involve environmental issues in the same way as for example, the biology subject. Gyberg also describes how energy education in physics is marked of the tradition of facts in physics and do not give the contents related to valued issues the same status.

RESEARCH QUESTIONS

The whole study aim to examine, *based on given frames, steering documents, subject content from Engström (2008a, 2008b), how and what physics teachers in Sweden teach*. We also ask *Are there any challengers*?

METHODS

The Selection Process

To reach all the physics teachers who teach Physics A we contacted all, 1025 secondary schools in Sweden, by e-mail. We informed about the study and asked questions designed to find schools giving the course during the academic year (2008-2009) and asked for physics teachers e-mail addresses. To schools that failed to respond after two weeks we sent a new e-mail with the same questions. Of the 1025 schools we have not received responses from 45 schools. The current e-mail list of 976 physics teachers (Physics A) was reduced (when the survey was closed) of the following reasons: that e-mail address ceased to exist; the teacher is on leave, sick, maternity or other reasons. The range covered by the survey, the respondent list amounts to 913 physics teachers (their e-mail addresses), but the selection may include the addresses of the persons employed by such schools or in municipals but do not teach Physics A, persons who don´t answer the questionnaire. As a web-based survey tool Netigate were used (http://www.netigate.co.uk/) and the teacher answered the questionnaire anonymously.

The preparation of the questionnaire

The questionnaire consists of seven parts and the questions are a mixture of open questions that require written answers and claims to be answered with either yes / no or choice of options. Alternatives are made of actual responses/opinions or claims such as in high grade / low grade, never / seldom / often, etc. The questionnaire includes questions and statements dealing with both *what* and *how* – questions (part 1 in the questionnaire) and questions giving empirical data for the analysis of *why the teachers do as they do* (part 2 – 7 in the questionnaire). Part 1 contains questions about the energy teaching practice in the course Physics A. In total the section includes 86 issues, claims, etc. in which the respondent is asked to take a stand. These questions have a background in and has been reworded based on the study on the topic content for teaching about sustainable energy in Physics A course (Engström, 2008a; 2008b). The questions aim to describe what is taught in terms of energy in Physics A and how teaching is carried out. Part 2 – 7 in the questionnaire are based on surveys made by Pierre Bourdieu (1984, s.512) and other researchers, all using the concept of capital etc. (Broady, 1998) for the analyses. The questionnaire was tested by four physics teacher (one woman, three men) who recently taught the course Physics A. Adjustments were made of certain issues out from their comments.

Tools for result generating and cluster analysis

From Netigate a report is obtained and a data sheet for statistic analyses program “SPSS” (http://www.spss.com). In the report all the variables are summarized in the response rates, presented in bar charts and in free text answers. The free text answers were coded for new variables presented in order to complete SPSS data sheet. The results from the Netigate – report, in which all variables are presented with response rates (also in SPSS data sheet, from which we get frequency tables), presents statements about what and how the physics teachers teach.

We also sought for groups or cluster of teachers using those variables that comprise the choice of teaching with a more valuating content (level D, E and F from table 1). This was done through a cluster analysis by SPSS where we looked for groups of teachers selecting the same subject content. In the cluster analysis we “cluster together variables that look as though they explain the same variance” (Field, 2000). We can explain a cluster analysis as a “way of grouping cases of data based on the similarity of responses to several variables” (Field, 2000). In this special case we made a hierarchical cluster analysis choosing Ward`s method (Squared Euclidean distance, Z-scored for variables, dendogram for presentation).

RESULTS

The response rate

When the survey was closed after six weeks the response rate had reached 29%. This was with three reminders and a personal letter accompanying the final reminder. The survey was answered by 268 persons and was opened and attended by another 222 people and was not opened by 423 persons. The empiric underlying the analysis and the result obtained in this study describes the circumstances of the particular group of 268 teachers. We cannot draw any conclusions as to whether the results are generalisable since there is no access to comparative national statistic for the agreed response rates over different variables such as gender, age, hometown size, education, and years of teaching and current home district. In general, the response rate among the 268 persons for each statement/question came to between 88 and 97 %.

WHAT DO TEACHERS TEACH IN PHYSICS A?

Figure 1 shows the percent of the respondents, and to what extent they respond strongly agree on the respective claim, to each level from table 1.

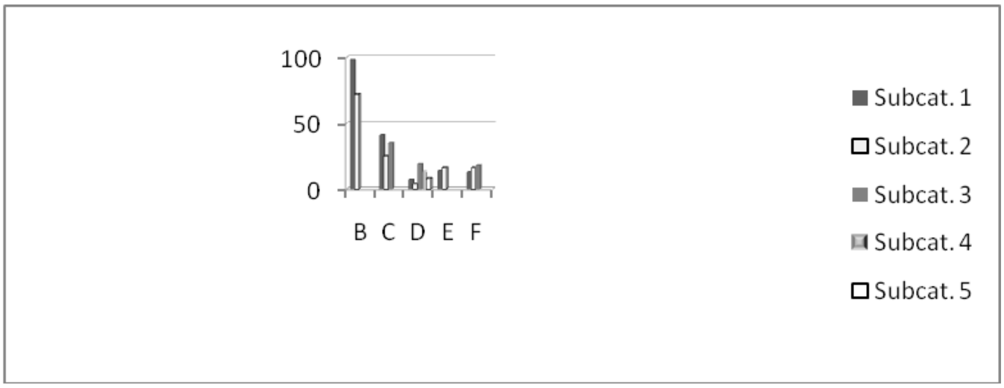

Figure 1. Percent responding, (responding strongly agree about teaching that content), per level in the structure of content.

Table 1. Levels from Engström (2008a, 2008b), a structure of content in energy education in physics.

F-level	More valuating content. Strategies and solutions for the future. 3 subcategories.
E-level	More valuating content. Problems. 2 subcategories.
D-level	More valuating content. Larger context driven by human activities and needs. 5 sub.
C-level	More fact in content. Basic science and technology, ”limited context”. 3 subcategories
B-level	More fact in content. Basic, traditional physics. 2 subcategories (sub. 1: basic energy concepts)

All teachers are teaching basic physics concepts but in summary, approximately 30% of the teachers *teach no* efficiency and environmental problems and strategies for sustainable energy, level E and F respectively. An exception is that 20% do not teach about future technologies. Significantly, almost 20% *refrain from* energy conversion phenomena such as heat engines and almost 70% *refrain* from energy conversions of for example biomass. Furthermore, interpreted the subject content related to environment, politics and ethics are missing. 79% of the teachers focus on the content with the aim that students will learn to calculate with the basic physics concepts and their relationships. Only 13% lets sustainable development guides the content of the energy component of Physics A.

How do teachers teach energy in Physics A?

The teachers say that it is important to build upon the curriculum and implementing it in teaching (72%). The course starts with the teacher having lectures, and then students may calculate and experiment in groups (69%, not true for 5%). Approximately half of all teachers *do not* let the students do work thematically. 22% give students the opportunity to in various ways put their knowledge of physics concepts in a wider context, for example, to link the phenomenon of global warming to climate change. Only 11% let the students work in groups with the course content that they adapt to current events in society and the media. 43% of the teachers let students' have their own discussions, both in group and when they have dialogue in the classroom. 23% give the students space to discuss and evaluate society's energy issues. About 16% of the teachers let the students be involved by determining the content and as many let the students work in teams with specific projects that can be related to concepts, etc. in the curriculum and want them thus to understand the concepts and contexts.

ARE THERE ANY CHALLENGERS?

The cluster analysis is based on *what* the teachers teach and resulted in 8 different teacher clusters. In the analysis we took as input what the teachers answered about teaching a more valuating content (level D, E and F, table 1). The mean value of each category for each cluster has then been calculated, out from the response from every person in the cluster. All questions for the categories have been used in this calculation to find what can be called a center of gravity in opinion. For each cluster we thus have three values, coordinates, to position the cluster in a coordinate system. If all clusters positions are plotted in a 3d-system with the D, E and F categories as axis they will roughly fall on a diagonal axis. In figure 2 we have projected this plot in two planes: D-F and E-F respectively. The figure shows that there are differences, for example that cluster 8 and 2 are with their positions polarized from cluster 3, 6 and 1. Cluster 4, 7 and 5 can be seen as describing something in between.

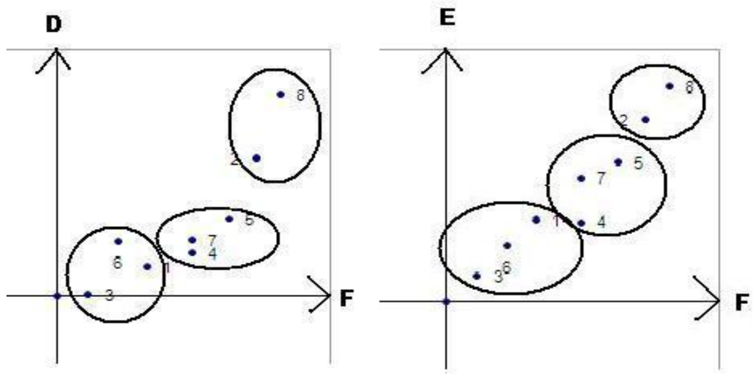

Figure 2. The positions of the 8 clusters in a system where the axis responding to content from levels D and E respective F. It shows the clusters distribution between themselves. For example cluster 8 teachers have a large amount of content from all D, E and F-levels. Cluster 3 teachers have nearly nothing of content D, E and F in their teaching. The elipses give how we out from the cluster analysis and response to the "how" questions, have presented the teachers in three groups.

After we found these clusters we put them in relation to *how* the teachers teach. With cross tables we found characteristic features. By doing a cluster analysis based on what the teacher teach and then finding common features for both what and how we have landed in *three* different groups. Generally we can see main differences between the groups concerning statements with numbers 20 - 34, expressed in table 2. The most distinctive results are visualized in bar charts, figure 3, 4 and 5.

Table 2. Statements from questionnaire. Numbers related to figure 3, 4 and 5. H=How, W=What

34	H	I let the students be involved and determine the content in energy in Physics A.
33	H	I let the students work in teams with specific projects that can be related to concepts, etc. in the curriculum, I want them thus to learn to understand the concepts and contexts.
32	W, H	I let the students work in groups with the course content that I adapt to the current events in society and the media.
31	W	I let the notion of sustainable development guide the content of the energy component in Physics A-course.
30	H	I work thematically in the energy part of the Physics A-course.
29	W	Students will determine themes or projects to work with.
28	W	I let the students have space to discuss and evaluate society's energy issues in Physics A.
27	W	My teaching is not directly related to the book. It is based on any current events in society, TV, article etc.
26	W	My way of teaching is based on students' own discussions, both in group and when we have dialogue in the classroom.
25	W	I do my own calculations examples adjusted to what I am talking about and what the students want to discuss.
24	W	I give room for and take a starting point in the students' experience in energy issues in society.
23	W	I read my remarks on the curriculum (physics), governing document on sustainable development, etc. and translate them into practical teaching.
22	W	I believe that students in Physics A, first of all should be developed for citizens to have a good understanding of energy issues.
21	H	I often use other teaching materials in addition to physics A-book in my teaching about energy in Physics A.
20	H	My way of teaching is based on letting students work more in groups, with both theory and in laboratory work.

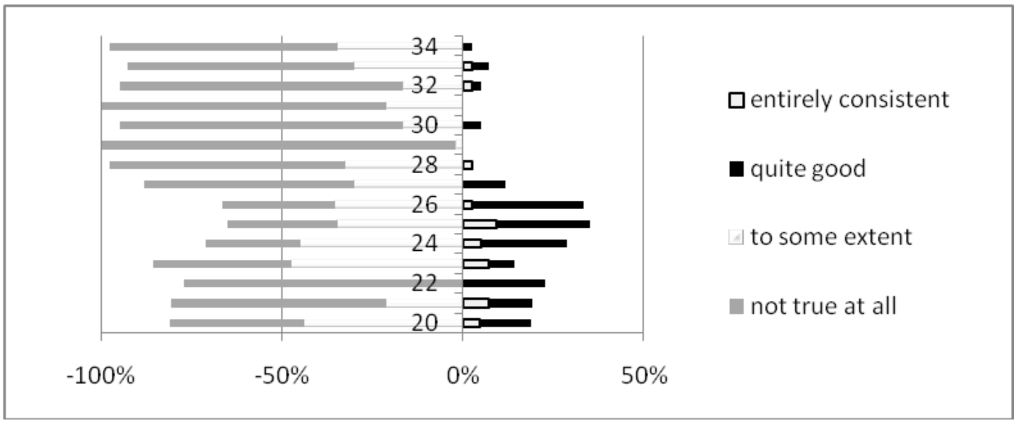

Figure 3. The Mainstreamer group. Example from cluster no. 3 in fig. 2.

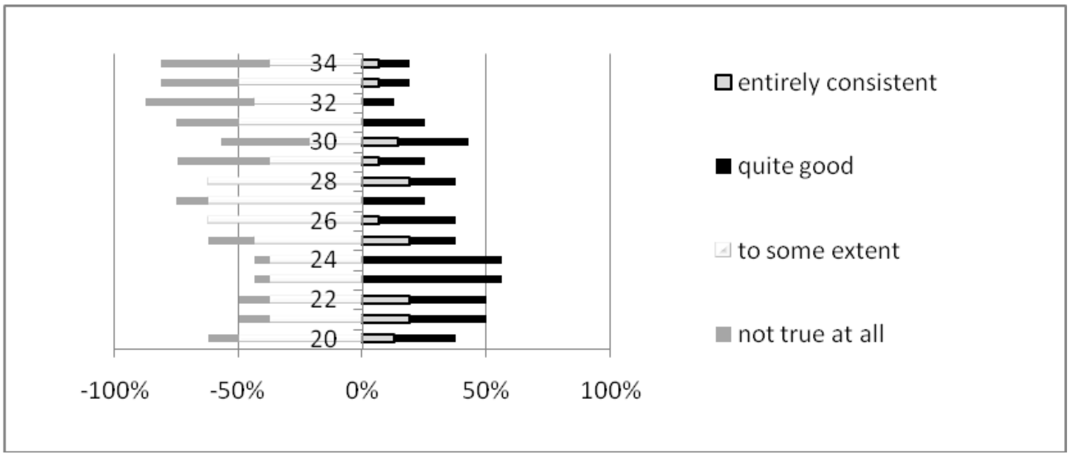

Figure 4. Future solutions group. Example from cluster no. 7 in fig. 2.

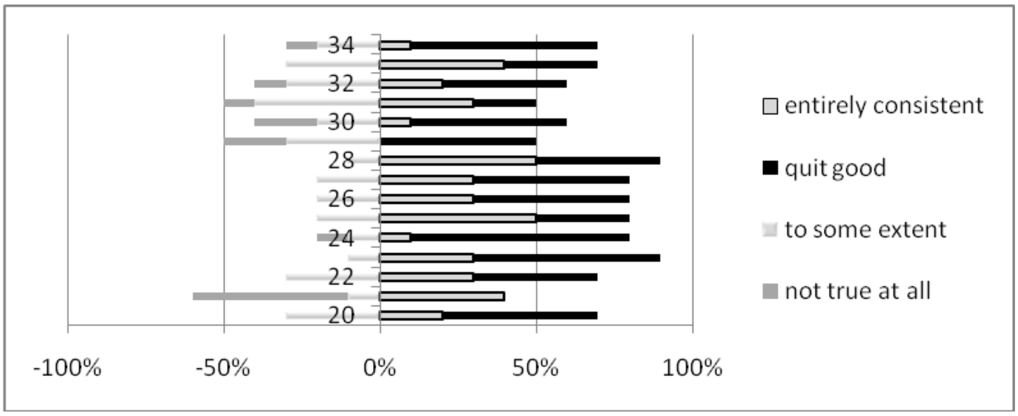

***Figure 5*.** The profile present answers from cluster no. 8 in fig. 2. *The Challenger group.*

A SHORT DESCRIPTION OF THE DIFFERENT GROUPS – WHAT AND HOW ABOUT TEACHING

The Mainstreamer group

The teachers we describe as traditionalists or mainstreamers includes 46% of the teachers. They teach nearly nothing of the more valuating content. However there is one exception; some of them teach about efficiency problems (15% in one of three clusters responding strongly). In another clusters there are three exceptions; teaching about efficiency problems (10% responding strongly), students own energy use (21%) and political issues (16%). Teachers in the last cluster teach nothing, without exception, of the more valuating content. For all The Mainstreamer clusters, the teacher *do not* let the students be involved and determine the content, work in teams, work in groups with course content adapted to events in society and media and they do not let sustainable development influence the content. They do not work thematically or give students space to discuss and evaluate society's issues.

Future solutions group

The group we call *the future solutions group* includes 39 % of the teachers and have clusters characterised by technology optimism, environmental issues respective teaching based on students experiences. One cluster teaches mostly strategies for the future, a large amount of solutions for the future and efficiency problems. But also about the students own energy use and economical aspects. Another cluster teaches about future solutions but also both efficiency- and environmental problems. The teachers in two clusters use to teach thematically and they want students to develop for citizens to have a good understanding for energy issues. They want to encourage their students to choose further studying in energy technology field and they let students discuss and evaluate society's energy issues. In this future solutions group we also find a cluster with teachers assuming the students experience and base teaching on student's discussions.

The Challenger group

This group consists of two of the clusters, totally 14 % of the teachers. The most clear challenger group includes the teachers that teach all of the more valuating content, 60% - 100% of the teachers responding strongly on every statement (related to level D, E and F in table 1). Sustainable development and actual issues in society influence their physics teaching. This group also includes teachers in one cluster that teach almost all of the more valuating content with only a few exceptions; some ethics and politics (only 12% responding strongly).The most clear challenger cluster also have students work thematically, in groups, with actual projects and they let students discuss and develop their own projects, see figure 5.

DISCUSSION

Generally the physics teachers in upper secondary school, physics A course, refrain from subject content dealing with context related to the external environment, energy flows in which human activities are included and context of policy-making, vision, human values etc.

The study resulted in "common features" for all physics teachers and their teaching as answer to the research questions about what and how they teach. These "common features" can be described as: The curriculum is steering the teaching, A standard text book in physics is used, The teaching is led by the book and the teacher deals with typical tasks at the whiteboard, The students do calculations individually and as homework, Group work is common for special issues: dealing with tasks from the textbook or laboratory work. Some teachers remain in these features within their teacher profession (meaning their pedagogical development and in their will to include issues of the society).The cluster analyses shows that these teachers correspond to a clear discernible and dominant group of teachers. But the analysis also shows that there are two other groups with descriptions including more than “common features”.

We can, relating to the research questions, say that the three groups diverge about the *What – question* but have more in common coming to the *How-questions*. For example the teachers appreciate group work and discussions in the classroom, but here we also meet some sort of limit of what is appropriate. Most of the teachers let the students discuss tasks from the text book about how they understand basic concepts and laws. It is not common to focus on the students themselves to determine the content of teaching, to connect the content to the current issues and to let students assess different energy solutions which are important ingredients in teaching for sustainable development.

The physics subject can be seen as a homogeneous, largely characterized by the ideal of scientific knowledge that one can observe and understand the proper laws of regularities in nature. This view is also illustrated as common among all physics teachers in this study as nearly 100 % of them report that they go through basic concepts, relationships and physical laws in their teaching. But with this study we have shown that there are physics teachers who teaches energy differently in the sense that they select a wider topic content compared to the "traditional" and that they include other teaching methods. These Challengers seems within the frame provided for the teaching of Physics A (curricula, textbooks, etc.) carry out a teaching including a valuating content, systems thinking, problem recognition, etc., without giving up on factual knowledge. The Mainstreamer group has an more internalistic view on their physics teaching while the Future group and the Challenger group can be described as having a more externalistic view (Frängsmyr,1984; Sjøberg, 2005). We connect these descriptions of teachers views (internalistic or externalistic) to Roberts (2008) two visions (I and II) about science education. The Challenger group looks on physics as something useful for both higher education and membership in society and furthermore important for insights about sustainable development. The Mainstreamer group teaches physics in a traditional way and give the students who find physics easy and interesting what they want.

In a coming paper the study is to proceed with these teacher groups and explore who they are and why they do what they do. Responses are sought both in the analysis of the questionnaire, and the analysis of the various fields which affect school physics such as politics by the governing documents, science and technology and science education field.

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A SOCIOLOGY OF SCIENCE FOR SCIENCE TEACHERS: BRUNO LATOUR AND STUDIES ON SCIENCE

Diana Farías Camero
Universidad Nacional de Colombia
dmfariasc@unal.edu.co

Manuel Molina Caballero
Universidad Nacional de Colombia
mfmolinac@unal.edu.co

José Carriazo Baños
Universidad Nacional de Colombia
jcarriazog@unal.edu.co

ABSTRACT

The significance of History and Philosophy of Science (HPS), as a medium used to strengthen scientific education within the population, has been vastly recognized. However, it has only been prioritized with regards to historical and philosophical respects in the pre and in-service teacher programs, giving second place to the sociology of science, which has even been viewed with suspicion by some researchers. We propose that reflection is necessary concerning taking the sociological perspective in science when educating teachers, and we highlight that the sociology of scientific knowledge, and especially the work of Bruno Latour and the "Studies on Science", can have an important pedagogic potential.

Keywords: *History and Philosophy of Science (HPS), sociology of science, Studies in science, Science teacher education, Bruno Latour.*

INTRODUCTION

One of the most important subjects in science teaching research is the debate concerning which ends and aims scientific education should currently strive for, a debate that places scientific competition and scientific literacy face to face, that is to say knowledge about the science vs. knowledge about the culture of science (Matthews, 2000). The History and Philosophy of Science (HPS) approach plays a significant role as mediator in this debate. Yet, when the time comes to incorporate HPS into the science curricula as a means to achieve new goals, other perspectives, such as those contributed by the sociology of science, have been largely overlooked; with a few notable exceptions, the fields of sociology of science and science education have existed in isolation (Cunningham and Helms, 1998).

In acknowledging that in the teacher's pre and in-service programs it is fundamental that science teachers know at least something about the history and the nature of the subjects they teach (Matthews, 1994), preference has been given to the epistemological aspects such as the tenuity of scientific knowledge, methodological plurality, theoretical weight in observation, the relationship between science and technology, science as a historic enterprise socially situated in the passing of time, characteristics of scientific reasoning and the rational reconstruction of scientific theories (Aduriz-Bravo, Izquierdo and Estany, 2002; Erduran, Áduriz-Bravo, Mamlok-Naaman, 2007). All the while sociological aspects are seen as juxtaposed with those of philosophy; sociology is used to distance the normative view of science from a descriptive perspective, the "how science should work" from the "how science really works in our society" (Zemplén, 2009).

The suspicious eye that many science education experts cast on the sociology of science is a product of the image it has within scientists, reflecting the various pressures and controversies it has confronted as a discipline, which in its beginnings decided to keep to the margins of science in order to make impartial, external observations, but that later took a "sociological turn" with which it then became more critical and "interfering" as it turned its interests towards the "social influences" that science has supposedly always been free of and on which it has founded its power and validity.

Initially, sociological research moved around the outskirts of "genuine scientific activity", using weak approaches that limited themselves solely to studying scientific misconduct from the social perspective, a stage known as the "sociology of error". To this initial trend belongs the work of researchers such as R.K. Merton, M. Orstein, H. Brown and D. Stimson, in the years ranging from the 1930s to the 1940s (Solís, 1994). These explanations based on causal powers, and which characterize certain types of scientific narratives, gave direct way for many philosophers to consider "external" sociological explanations to science, justifying a division between the internal/external side of science and in which the "rational", "epistemological" or "cognitive" should be in opposition to the "social" (Rouse, 1991). This tension has propagated to the nature of science, bringing an ideal science against a real science, that of epistemic norms to that of historical practice, that of philosophers to that of sociologists, on a balance scale that as seen previously, is tipped to one side by science teaching.

Laudan (1986) criticised and explained, from a position based on the principle of arationality (a demarcation criterion through which sociology of knowledge can intervene to explain beliefs if and only if those beliefs cannot be explained in terms of their rational merits), this Gordian knot in which sociology has tended to consider many episodes of history of thought irrational (and hence, sociological), that are, according to other models of rationality, completely rational. This tendency strengthens the debate between rationality and irrationality, a clash that according to Allchin is not an armchair intellectual debate but rather a power struggle. "It is about the scope of authority of science. Hence, the discourse typically evokes deep emotions. Under standard protocol, one first declares one's allegiances, so that everyone knows whether to treat the speaker as a hero—or to despair that they have succumbed to some imagined "axis of evil" the roles assigned alternately, according to perspective" (Allchin, 2003: 936).

This conflict, which has a part in the so-called "Science Wars", and because of its purely political connotations and origins should have been kept far from the educational environment, is unfortunately present in science teaching. Thus, a great number of researchers have taken the side of giving the role of the villain to the sociology of science. Slezak (1994a) does not hesitate to declare that the claims of contemporary sociology of scientific knowledge (SSK) bring with them serious, educationally and culturally deleterious implications for the rationale and practice of science teaching, hence, science teachers should resist admonitions to accept the findings of the sociology of science; and at the same time describe the moral and intellectual depravation of the SSK, due mainly to its historicist, contextualist, and relativist view of scientific theories. He also declares that there is little reason to take these views seriously, though their widespread popularity is cause for concern among science educators (Slezak, 1994b). Similar opinions characterised in many cases by associating relativism with sociology of science are shared by other researchers like Irzik and

Irzik (2002); Izquierdo (1996), Izquierdo and Aduriz-Bravo (2003); Kragh (1998); Mathews (1994,1997) and Solbes and Traver (2003).

These positions against the sociology of science are discussed by other researchers who take the responsibility of highlighting certain aspects such as the importance of the sociology of science in describing human relationships, beliefs, and values that pervade science, challenge stereotypes and erode the unwarranted status and permanence of science to stress human and societal components and context (Cunningham & Helms, 1998). As such, sociology should not be considered as opposing science or the scientific world-view, but instead could be used to form the basis of a well-informed view about science (Zemplén, 2009), and for developing informed citizens (Kelly, Carlsen and Cunningham, 1993). Moreover, science cannot be divorced from its human context, since it is, above all, a human activity (Allchin, 2003). In fact some of them have even developed research studies in which they have shown the positive role the inclusion of the sociology of science plays in the classroom and formation of teachers (Barab and Hay, 2001; Cunningham, 1998; Zemplén, 2009).

Cunningham and Helms (1998) state that the considerations which originate in the sociology of science should reach the students, since ignoring these understandings not only misrepresents science, but also differentially discourages certain populations of students from further science study. The mythical image of science as the “impossible” field to which only a few privileged “geniuses” who know mathematics can gain access to can avert students from science as a case study by Calabrese-Bartn and Yan (2000) has clearly demonstrated, a case which could quite easily be that of many students. Some classes in which the sociology of science has admittance can make science study more democratic, thus it should be rated “E”: Essential for Everyone (Allchin, 2003).

How then, do we reconcile this dichotomic position between a sector of science teaching that sees a relativist, postmodern, skeptic, etc. risk in incorporating the sociology of science in the science classroom, and those who see such an incorporation a necessity? More so, when it can be declared that this dichotomy springs from an older one, product of power relations, a political battle, between the rational and the irrational, between the normative and the practical, between philosophy and the sociology of science? How can we make decisions when the conflict gets lost in profound “reflections” that don't overcome the range of rhetoric or the provocation between the two sides? For Allchin (2003) the key is in dismantling the mythic impression that to be “social” or “constructed” is to be irrational or relativist and instead look towards the work of philosophers who, motivated by the feminist critique, have made contributions in trying to understand the epistemology of the sciences from other outlooks. This includes the work of those such as Sandra Harding, Helen Longino and Miriam Solomon, who have shifted epistemic norms beyond the individual, to include the social, or of Andrew Pickering who emphasizes the significance of human agency in the presence of the imminent fact of the impossibility that science occurs without scientists. Also, highlighting the ideas of Bruno Latour, David Hull and Alvin Goldman, who help strengthen the philosophical view of science from a sociology perspective.

For us, the key is in accepting the risk of including the sociology of science as another ingredient in science education, in the same way the importance of philosophy and the history of science have been recognized, as well as in considering the potential of one of its facets that is rarely discussed, but that is necessary in science education: the emotional dimension. For us this aspect can be vastly explored in the work of Bruno Latour and thus we present a few considerations regarding his thought, with the aim that they be a point of reflection and maybe even an inspiration in science teaching.

LABORATORES, CONTROVERSIES, BLACK BOXES AND NON-HUMANS

Taking a tour through the thinking of Bruno Latour implies a movement through different moments in the sociology of science that followed the works of Kuhn. A discipline that instead of studying the reactions between scientists, the reward system and and institutional affiliations, decided to move to showing the fundamental social character of objects, facts and discoveries of science, the sociology of science became the sociology of scientific knowledge SSK (Latour and Woolgar, 1995).

Nieto (1995) describes the SSK as a program of critical research that was not interested in analysing the finished products of knowledge, but rather in the process of their fabrication; it changed from searching for formal criteria of demarcation and legitimacy to setting out to explain in a casual fashion the existence of all types of knowing. Inside this tradition it is assumed that scientific knowledge is a social construction, where science is subject to and depends on the conventions and negotiations, on the interests of individuals and specific communities, and that said conventions and interests can and should be explained. Golinski (1998) explains that for the SSK scientific practice is viewed as having an indefinite lifetime and overdetermined, and that scientists are not obligated by logical deduction of present beliefs or biased evidence to develop their ideas towards a particular direction, being able to make practical judgments that can be sent down to their local subculture where there is an investment of resources and skills in order to reach the ends pursued.

In line with the SSK are the works of Barry Barnes, Donald MacKenzie and David Bloor from the School of Edimburg, who constitute the nucleus of the sociology of science's Strong Programme and with which it's primarily associated, especially by critics such as Slezak. Nonetheless also part of the SSK are the works of Steve Shapin and Simon Schaffer who base their sociological research in the empirical study of controversies instead of in a social traditional history, and that of Harry Collins, one of the pioneers of the investigations around scientific controversies in the 1970s, for whom scientific facts can be explained socially leaving aside the arguments that appeal to the impersonal rules of experimental procedure. The importance of these controversies has been recognized in science teaching (Kipnis, 2001; Mathews, 1994).

For Latour (2008) the study of the innovations and controversies has been one of the first privileged places where it was possible to maintain objects as visible mediators, distributed, referred, by more time, before they became asocial and invisible intermediaries. Latour and Woolgar (1995) explain how the facts are constructed in such a way that once the controversy stops, they are taken for granted, and after the controversies end the unique things that remain are claims lacking author, lacking judgment or polemic and even lacking any reference to the experimental mechanism that generated them. At the end of the controversy one goes from the angriest controversy to the tacit knowledge, the step is progressive and continuous - at least when everything passes with normality, which by all means happens rarely. These authors insist on the fact that “while there are plenty of controversies, nature is never used as a final arbiter since nobody knows what it is or says.

But once the controversy is closed, nature is the decisive arbiter" (Latour and Woolgar, 1995: 94).

Another one of the aspects of the SSK in which Latour has made important contributions is that of etnomeotodological research. The 1976 Bruno Latour and Steve Woolgar's *Laboratory Life*, was a pioneering study in the field of ethnographic studies of specific research laboratories, which indicated a different path towards a sociology of scientists, in opposition to the traditional sociology of science, which limited itself to studying patterns inside disciplines, institutions, ethics, public understanding, reward systems, legal disputes and only with great prudence proposed to establish "some relations" between some "cognitive" factors and some "social" dimensions, but without insisting too much on it (Latour, 2008). This study was followed by the works of Karin Knorr-Cetina and Michael Lynch, at the beginning of the 1980s, the first sociologists who worked in studies of direct observation of the practical works done between experimental scientists. These researchers looked to vindicate the idea that the interactions between small groups are not less "social" than the forces on a large scale (Golinski, 1998).

These works, in the core, implied a redefinition of the term "social" which now dealt with different phenomena from the evident influence of the ideology, the scandals or macroinstitutional factors of science, factors that scarcely explain the fact that science's social character is explained in the idiosyncratic, local, heterogenous, contextual and multifaceted character of the scientific practices (Latour and Woolgar, 1995). For Knorr-Cetina (1981) there are many surprises that await us when entering a laboratory to study a group of scientists. The idea that this enterprise can be easily defined in some idealised epistemologic terms is refuted, this preconception crumbles when the ethnographer is able to see that the success in making things work is much more mundane than that of the search for the truth, which is never finally reached. Ethnographic research is a realistic task that tries to truly represent the social order of life in the laboratories and research institutes just as they are, this approach is much different from trying to explain science macrosocially since it allows us to understand the contingent and contextual features of its products.

When entering the laboratory, ethnographers were faced with the fact that the rational/social dichotomy was obsolete, that the distinctions between the cognitive and the social, the technician and the professional, the scientific and the non-scientific, were erased in scientific practice constantly; that the traffic between the social and technical or scientific areas was also subject to scientific negotiation, that it could be more clearly glimpsed if the research was directed towards scientific production on course before being directed towards its historical descent, and so the emphasis was put on considering scientific products like the first and the more important result of the "cognitive" operations, which are mediated by a social process of negotiation located in time and space, instead of on the taking of an individual logical decision (Knorr-Cetina, 1981). The main idea was that "scientific activity was not 'about nature', but a fierce fight to construct reality and the *laboratory* was the place of work and the assembly of productive forces that made possible such a construction" (Latour & Woolgar, 1995: 272). Many of these points have been criticized widely by Slezak (1994b), but as Alchim (2003) suggests, it is now the hour to stop interpreting that everything that contains the terms social or constructed implies irrationality or relativism.

His ethnographic experience allowed Latour to understand that the realm of the construction of science goes beyond the walls of the laboratory and the rising dichotomy between the micro and the macrosocial. Thus, in *Science in action* (Latour, 1987), he presents the bases of his new program: *Studies on Science*, that constructing on and extending the SSK bases, distanced itself from the radical way of the sociological project and it decided to go beyond being a reflection on science to include the general problem of the social order (Domènech and Tirado, 1998). In later works, Latour has extended his questionings and explanations about the total objective of the social explanation of scientific practice, suggesting neither the aim of the explanation nor the categories to which usually the sociologists appeal would have to be maintained. Latour demands "a turn more, after the social turn", that become real in his program (Golinski, 1998).

The program of Latour describes how the practices in which scientists and technologists are involved reshape the social world at the same time as they create natural knowledge, the reason for which it is unsuitable to invoke sociological categories to explain scientific practice. Instead of taking care of those overambitious causal explanations, the analyst must simply "follow" science and technology professionals in the way they manipulate material, social, and linguistic entities (Golinski, 1998). For Latour (2001) the *Studies on Science* are able to reveal, *a posteriori*, all the work that scientists and politicians had to do to become themselves in a weave inextricably united; the work of the "social" researchers does not consist in affirming *a priori* that "some connection" between science and the society exists, since the existence of this connection depends on what the actors have done or ceased doing to establish it. *Studies on Science* simply provides a way to disclose this connection when it exists.

In the proposal by Latour (2001), one that is not totally sociological, but neither totally philosophical, the scientific adjective is the one that defines access, by means of experiments and calculations, to entities that in the beginning did not have the same characteristics as humans do, here science changes entities that at the outset are alien to social life and which soon go little by little to being socialized (the nonhuman ones), starting to live between us, through the bridges tended by the laboratories, the expeditions, the institutions and others, just like the last historians of science have very frequently described. For Latour, the discussions about science have became to be questions over *logic* (is it a straight or curved path?) from *sociological* questions, (is it a more or less solid association?) where it is possible to study how the causes and the effects are determined, which elements are related to each other, how large and resistant the bonds are, among others. Latour calls sociological issues to answer these questions and the only thing that is said to be known about these trajectories is where they go, how many people cross them, with what type of vehicle they travel and if they are comfortable to travel, not if they are correct or if they are mistaken.

This process of "tracking" breaks down the idea that scientific speech is purely literary or fictitious owing to the possibility of resorting to the laboratory instruments that produced the original "inscriptions" represented in the texts. It is possible to see also how these instruments are "blackboxed" and soon go from user to user, increasing their authority as long as they move away from their place of origin. In the eyes of Latour the facts and the machines are transmitted in the same way, going through the chains people tied through networks that make the movement from local knowledge to *technoscience*'s labs around the world possible and that allows the reformed world which reassembles the special devices of which the material artifacts are done to be seen. Hence, that the facts and the machines are able to survive in a world beyond the walls of the laboratory (Golinski, 1998).

For Latour (1987) the “solid facts” or the “highly sophisticated machines”, or the “powerful theories” or the “unquestionable evidences” are black boxes. All these terms that allude to strength and power, indicate clearly the immense number of associations reunited in these boxes, so out of proportion, indeed, that it is what maintains the multitude of allies in its place. The impossible objective of opening the black box becomes possible (if noneasy) if the researcher moves through time and the space, until he/she finds the controverted subject in which the scientists or the engineers hardly work. Thus instead of locking up the technical aspects of science in that box and looking for its social prejudices and influences *after*, it is more favorable to be present *before* the box is closed and it becomes a blackbox. The black box, that simplifying device about which we did not need to know more than the entrances (inputs) and the exits (outputs), must be opened, without paying concern to the how controversial its history is, how complex is its operation, or to the extensive, commercial or academic, network that supports it.

So, the important choice is to make the entrance through science and technology by the back door of science in-the-making, and not by the more imposing of processed science. Latour in *Reassembling the social* explains: “The process of “making of” any enterprise offers a vision that is sufficiently different from the official. Not only it takes to us behind scene and it makes us know the capacities and the tricks of the professionals, but also it offers a rare vision of how it is that a entity emerges from the nonexistence when its temporal dimension is added. Even more important when one crosses a construction site undergoes the disturbing and exciting sensation of the things could at least be different, or that still they could fail; sensation that never is so deep when one faces the ended product, by beautiful or impressive that is” (Latour, 2008: 132)

LATOUR FOR THE SCIENCE TEACHING

Of the works of Latour, that as a group of professors of chemistry interested in the Didactics, we have been able to read, to analyze and to enjoy there are three aspects that we considered valuable and that can be exploded in science teaching: 1) The implications to work shoulder to shoulder with the scientists, 2) The role of the historical reconstructions, the “black boxes” and their relation with the contents of science textbooks and 3) The empathic and affective implications to grant agency the nonhuman ones.

Latour confers a great importance to the practice of science and to working closely with the scientists. From his two-year stay in the Salk Institute with a group of investigation in neuroendocrinology directed by Roger Guillemin, who would later go on to gain the Medicine Nobel Prize in 1977, and that is documented in *Laboratory Life,* and from his expedition in the region of Boa Vista in the Brazilian amazonian forest with a group of edaphologists and botanists who carried out a study on the dynamics of the vegetation and the differentiation of the ground that appears in the second chapter of *Pandora'a Box*, Latour describes, analyzes and establishes relations about the complex that is science and the scientific work.

The reading of those two texts mentioned previously motivates us to know the scientific work *in situ*, to think about science like a process that can be very local and simultaneously have unsuspected reaches, and first of all it motivates us to leave the classroom to go in search of the scientists, those characters who move like managers or administrators, but who also can be in front of “strange” equipment and their registries, while they make political decisions that can guarantee the continuity of their projects. Volante, de Almeida and Queiroz (2007) explain how after reading a few chapters from *Laboratory Life*, a group of students change their conception that to be a "scientist" is "to be in the laboratory" and understand the complex range of activities that a scientist must carry out along with purely experimental work.

To work shoulder to shoulder with the scientists, as Barab and Hay (2001) describe when presenting the results of the project Science Apprenticeship Camp (SAC), can be a way to engage students in authentic scientific inquiry, to allow them to gain understanding of the communal nature of science, and to facilitate the adoption of ways to perceiving and interacting with the world that are consistent with those of real scientists. To work with the scientists changes the conception it means to learn sciences, moving from the memorization of decontextualised facts and skills described by the professor or texts to the appropriation of the socially contextualised practices of a community. Moreover, this direct emotional relation with science can help to break certain myths, those that create abysses between an idealised science and the students and teachers.

With just seeing what scientists do and how they do it, and trying to track down where all the elements tied with their work go and come from, (resources, equipment, personnel, institutions, allies, molecules, bacteria, etc.) it is possible to conceive the complexity of science and to associate it with the networks with which Latour has tried to explain it. The important thing in this point is: *that real approach with the scientists and all its advantages (including the emotional one that consists of recognizing the scientists as human beings) should be considered like part of the sociological component in the pre and in-service programs,* and also, we consider the fact that the experience of the scientific practice can serve to reinforce, thanks to the discussion with who makes science, the epistemic concepts as Allchim (2003) asserts, that is to say, that through the scientific practice sociology and philosophy are complemented, and so with certainty, any effort that is made in this sense will have a positive yield in the classroom.

With respect to the second point, we want to point out that certain claims done by Latour must be considered in the sciences education: the use of the historical reconstructions and the way these are presented in science textbooks. Important aspects arise from his analysis, about the history of science, the protagonists of that history, how it is made official, and how it is sterilised and packed in “black boxes”.

There are two historical cases on which Latour has written widely: one on the scientific controversy between Louis Pasteur and Felix Pouchet and one on the entailment of Frèdèric Joliot with the project for the constructing an atomic reactor in the heat of World War II. Both cases are presented in the History of Science, edited by Michel Serres (Latour, 1998a; Latour, 1998b), but they have been boarded from different approaches in other publications (the case of Pasteur in the Pasteurization of France (Latour, 1988) or the Pandora's Hope (Latour, 2001) for example). The reading of these texts would have to be essential in any pre and in-service program, because it provides an interesting discussion about the role of controversies, specifically when the times comes to analise the history that appears publicly, a history of winners, great men (no women, of course) and of heroes.

Latour and Woolgar (1995) point out that when researchers (especially historians) only address science products, the facts, they have the easy task, that is, “they arrive after the battle and they only need a reason to explain the failure that leaves defeated in the controversy” (Latour and Woolgar, 1995: 97). A claim that already had been done by Ravetz

(1973) when he affirmed that the history of a controversy must be carefully processed not to present the victorious side (retrospectively) of the resulting theories, like lawyers for the obvious, while the losers are slandered, and at the same time compelled to allow their failures open their eyes to the truth, and so the task of the history of science becomes re-encountering the victories that lead them to the establishment of the standard knowledge in science textbooks.

Latour and Woolgar (1995) explain: “In a certain sense the historical explanations are necessarily literary fiction. Just as it appears in textbooks, the historians can move freely through the past, own knowledge of the future, have knowledge of the future, have the capacity to examine scenes in which they are not present (and never they will be), have access to the motivations of the actors, and (as God) be omniscient and omnipresent, able to judge the good and the bad. They produce histories in which a thing is the “sign” of another one and in which the disciplines “bloom”, “mature” or are “rejected” (Latour and Woolgar, 1995: 121). The history of the science that we use in our classes and that is present in the training materials, in some cases with the aim to motivate our students, in order to present hard sciences in a smoother way, more human and therefore to make it more popular, as indicates Kragh (1992), can not only reduce the historical dimension of science to the chronological level or anecdotal but it can, on the emotional level, transmit an idealised image of science where there are only winners and where the beaten ones do not at least have the right to being mentioned, an image of science which for some can be injurious between students. *The pre and in-service teacher programs would not have to be satisfied with teaching the advantages of historical reconstructions, a sociological critic about them and of how they appear in science textbooks is necessary.*

Finally we want to mention the microbes, “the microbes of Pasteur”. Latour describes them like decisive allies in the war between Pasteur and the spontaneous generation, a war that this one lost between 1860 and 1864. Latour unlike other sociologists of science confers it a special role in the scientific activity to which denominates the non-humans. Molecules, microbes, diesel engines, neutrons that in a deterministic moment in the scientific work have been fundamental. Non-humans that are also mobilized in course of the controversies and if lacking would generate “different histories”.

Latour gives agency to them, a concept that until then had been exclusive to humans and in addition it emphasizes how highly social they can be thanks to science, allowing them to leave the place they where always hidden in and and to go to live between us. To read the texts of Latour that speak of Pasteur and his microbes is an exciting experience that although certainly resembles a novel story in some cases, (sometimes science is thus), it allows us to see the history of the science in another way. It is simply impossible to not “fall in love” with the microbes as the story advances. That empathic aspect that is shown recognizing that science is not only one human enterprise but there are “others” that take part in it and constitute it “socially” is something different from that which has been usually sold to us, it is what we highlight as one of the most important points in the work of Latour.

It is important from the point of view of whom and how we are today teachers and students, very different from the students and teachers of fifty years ago for which educative systems were designed in which still we are immersed. “Postmodern” students and teachers living in a world which surround us by the “products” of science, a world in which the differences between science/technology are no longer so evident, where the barriers between all the categories and dichotomies we once had are lost almost completely, a world where our students do not want to know of science and in which a little empathy and affection, by those nonhuman could even be the key to make engage them in science.

In the end what Latour teaches us is that next to those solitary scientists whom official traditional history has been in charge of to present to us. Locked up in its laboratories are immense amounts of people, resources, institutions and obvious non-humans that today make possible that their names be what they are, is only necessary to investigate better and to follow the threads that science is leaving its step. It also teaches us to think about science as something more complex beyond all the "black boxed" theories, concepts, products and processes and invites to us to know more, to want to see science like something social, just now what someone in the past insisted on separating is the hour to return to reunite it. *Any teacher program of NOS would have to be directed to motivate the teachers, to reunite again nature with society.*

CONCLUSIONS

In this work we have attempted to give a tour of the thought of Bruno Latour, along with the development of sociology of science in the Pos-kuhnian Era. In spite of not basing our claims on own empirical research we consider, through theoretical reflection, three aspects of the work of Latour to have great potential in pre and in service teacher programs:

1. Personal experience of teachers with scientists in the setting where science is carried out
2. Critical sociological reconstruction of the history of science, especially of the one which appears in textbooks
3. The need to understand the enduring relationship between the social and the natural

These three topics present in the work of Latour are expressed in the emotive, a dimension that has been consigned to the second plane in science education and that should be recovered in the teacher programs with the aim of drawing closer and demystifying the science with which we want our students to engage.

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WHAT DO PRE-SERVICE TEACHERS THINK ABOUT VISUALIZATIONS AND IT'S USE IN CHEMISTRY INSTRUCTION?

Celeste Ferreira

Faculty of Education, University of São Paulo, São Paulo, Brazil

rsilva1111@yahoo.com

Agnaldo Arroio

Faculty of Education, University of São Paulo, São Paulo, Brazil

agnaldoarroio@yahoo.com

ABSTRACT

In science and science education the interest and the use of visualizations has increased greatly in recent years (Gilbert, 2005; Ferk & Vrtacnik, 2003). The reasons for this growth are very well known and consensual: the exponential rise in the memory capacity of personal computers and the associated investment made in software development and the increasing belief that visualizations some how help pupil's learning. So in this new teaching environment, educators introduce several types of visualizations in their own classes with the purpose of getting better learning results. On this work we try to understand what a group of pre-service teachers think about the general use of visualizations in chemistry instruction and the specific reasons and thoughts that underlie their own choices as teachers in a mini-course that they presented to middle pupils at S. Paulo's University, Brazil. The research indicates that these pre-service teachers had a weak theoretical knowledge about this issue; their conceptions are superficial and based mostly on their experience as pupils. We can also say that based on recent research (Wu, Krajcik & Soloway, 2001; Gilbert, 2007; Briggs & Bodner, 2007), they show misconceptions about this issue, such as: don't recognize the cognitive value of visualization or the knowledge of codes and conventions of representations. Therefore there is a high risk of using visualizations inappropriately and it will lead to serious fails in pupil´s apprenticeship.

Keywords: *Visualizations; Chemistry instruction; Teacher's conceptions.*

INTRODUCTION

The use of visualizations in chemistry instruction became a new field of research. In the last years, four very different groups of people (computer software specialists, scientists, educationalists and cognitive scientists) have promoted the development, the discussion and the use of visual tools in sciences instruction (Gilbert, 2007), nerveless research evidences are only in the beginning. There are more questions than answers. The role of models and visualization in science and science education has been discussed in the last years in several studies: what to study, how to do so, what constitutes good practices, or how to evaluate the outcomes of that practice are some of the challenges that researchers have faced and will continue to face in the next years.

There is a central topic that often crosses these studies which is the definition of the term "visualization". According to Gilbert et al (2008) there are two conventions, in convention 1, visualization is a verb (to visualize something is to mentally act on it), in convention 2 visualization is a noun (visualization is something in the public realm). Inevitably, there are also studies that cross the two conventions, for instance, studies about “visuospatial thinking”.

We found literature approaching this issue in the sense of convention 1 that dealt with questions such as: How is a visual representation turned into knowledge? What are the mental processes that are involved in attaching a meaning to a representation? What mental and brain processes are involved in “seeing”? (Reiner, 2008). Other authors (Gilbert, 2007; Rapp, 2007; Rapp & Kurby, 2008; Briggs & Bodner, 2007) also present their ideas about these concerns. Gilbert refers the importance of developing “metavisual capability” or “metavisualization”, the acquisition of fluency in visualization and the making of meaning for any representation (Gilbert, 2008). This author suggests that this development could be done by general good practice in the use of representations by teachers and in textbooks and by the specific cultivation of the skills involved (Gilbert, 2007). For Gilbert the skills involved are: being able to move fluently between two-dimensional and three-dimensional representations of a given model (translate); being able to mentally change the perspective from which a given three-dimensional representation is viewed (rotation); being able to operate on the representation itself, particularly in terms of taking mirror images of it (reflection and inversion). This author also suggests that in order to become metacognitively capable in respect of visualization, pupils should:

- *Know the conventions of representation, both for the modes and major sub-modes of representation that they are likely to encounter;*
- *Know the scope and limitations of each mode and sub-mode i.e. what aspects of a given model each can and cannot represent; (Gilbert, 2007, p.21)*

One problem with this approach is the difficulty to evaluate the pupil’s status in respect to metavisualization, in order to solve this problem Gilbert suggests the use of some available tests for assessing competence in some of the key aspects of visualization at the lower level of metavisualization. In this lower level:

> *‘An individual is capable of: reflecting about many features of the world in the sense of considering a comparing them in her (sic) mind, and of reflecting upon her means of coping with familiar contexts. However she is unlikely to be capable of reflecting about herself as the intentional subject of her own actions.’ (Von Wrigth, 1992) (p. 60-61) (quoted in Gilbert, 2007)*

Assessing performance at the upper level of metavisual competence could be done by interviewing the pupils as the tasks in the tests are being completed. At the upper level, an individual is capable:

> *‘Reflecting about one’s knowledge or intentions involves an element which is absent from reflections about the surrounding world. Self-reflection presupposes, in the language of mental models a ‘metamodel’: in order to reason about how I reason, I need to access to a model of my reasoning performance’ (Von Wrigth, 1992) (p. 60) (quoted in Gilbert, 2007)*

Using another approach Rapp and Kurby discuss the importance of the construction of mental models by the pupils. Without these models learning becomes very difficult, especially in chemistry. In Rapp (2007) this author discusses the construction of mental models related directly to the use (and potential) of visualizations as educational methodologies. Rapp presents mental models as abstract representations that store the spatial, physical, and conceptual features of experiences, useful for retrieval in the service of problem solving, inference generation, and decision making. He goes deep and points:

> *'In summary, mental models are internalized, organized knowledge structures that are used to solve problems. They are encoded with respect to the spatial, temporal, and causal relationship of a concept. They can be run to simulate that concept, in order to assess alternative viewpoints and consider possibilities not readily available or apparent.' (Rapp, 2007, p. 46)*

In Rapp & Kurby (2008), these authors try to make the connection between 'external representations' and 'internal representations' and relate these studies to educational situations. How to draw effective visualization experiences that help pupils internalize those visualizations and achieve learning? For these authors the solution maybe:

> '*By designing 'visualizations' in ways that align with the nature of memory, it may me possible to more effectively help pupils understand those challenging concepts. In addition to finding better ways for pupils to learn complex concepts, 'visualizations' may also aid pupils in dealing with unfamiliar, but potentially related, problem solving situations.' (Rapp & Kurby, 2008, p. 48)*.

In this line of studies we find also two authors (Briggs & Bodner, 2007) that point out again for the construction a mental model. On their qualitative research, while working on each tasks the participants were encourage to verbalize what they were thinking at the moment, they conclude that when participants were working on a mental molecular visualization/rotation task they invoke components of a mental model. They identify four static components: referents, relations, results and rules/syntax, and a fifth dynamic component: operation. They refer also that participants use the constructed mental models as mental tools to complete the task. From these outcomes these authors also claim that:

> '*Improper visualization may cause flawed representation and lead to incorrect results. This is an important lesson to teachers. We must be very careful of the manner and precision with which we scaffold our pupils as they construct their mental models of domain-accepted concepts. A flawed mental model can have an impact on reasoning beyond what one might expect.' (Briggs & Bodner, 2007, p.70)*

These are some of the key ideas that we found in literature, several other authors and studies work on this trend providing insights into understanding the process of visualization, and into designing the learning environments in a manner that is adaptive to the behavioral and brain processes known data.

Like we mentioned before, there is another trend of research that uses the term visualization in the sense of convention 2, a noun, something that has been placed in the public realm in either a material object, visual, verbal or symbolic form. Here we found several studies (Wu, Krajcik & Soloway, 2001; Ferk et al, 2003; Santos & Greca, 2005; Tasker & Dalton, 2006; Savec, Vrtacnik & Gilbert, 2007; Kozma & Russel, 2007b; Arroio & Honório, 2008) that by using a different approach try to evaluate the use of different kinds of visualizations in chemical instruction. Most parts of these studies are only quantitative and through a series of specific tests they try to evaluate the pupil's apprenticeship and indirectly the effectiveness of the visualization used.

Therefore, we began to encounter some studies where a component of qualitative research is introduced. The aim of this introduction is to obtain rich information of how pupils develop an understanding of chemical concepts while using visualizations as helping tools in learning. A great part of these tested visualizations are software with virtual 2D and 3D images and in a few cases animations and simulations or combinations of various representations (e.g. concrete three-dimensional models, virtual computer models, static two-dimensional computer models, stereo-chemical formulas).

We also found an interesting work that talks about the need to develop “representational competence” (Kozma & Russell, 2007a) in the pupils. This term is related to the skills and practices that are needed for a person to build and use a variety of representations or external visualizations, to think about, to communicate with their peers, etc. These authors also present an investigation (Kozma & Russell, 2007b) using five chemistry multimedia visualization projects using different approaches. The authors conclude that all five projects shown an improvement in the learning of chemistry concepts and development of scientific investigative process skills. In this work the authors left some recommendations for visualization-based instructional activities which we highlight: there are no carefully designed experiments that tell us when it is best to use animations versus still pictures or whether dynamic molecular models are better than physical ball-and-stick models. There is no data about the precision of how these various media can be used together and when is best to do so. Now days, all these practical issues are left up to the judgment of instructors and instructional designers.

According to what we have referred before, we also find studies that cross these two conventions and try to examine the role of visuospatial cognition in chemistry learning (Wu & Shah, 2004). This interesting work shows that visuospatial abilities and more general reasoning skills are relevant to chemistry learning. They also conclude that some of the pupil’s conceptual errors are due to difficulties in operating on the internal and external visuospatial representations and some visualization tools have been effective in helping pupils. This study also presents five principles for designing chemistry visualization tools: (1) providing multiple representations and descriptions, (2) making linked connections visible, (3) presenting the dynamic and interactive nature of chemistry, (4) promoting the transformation between 2D and 3D, and (5) reducing cognitive load by making information explicit and integrating information for pupils. With these five principles the authors expect to enable us to help pupils understand chemistry concepts.

In the mean time teachers introduce these tools in their classes, sometimes without the necessary and desirable training on these subjects therefore contributing to the unsuccessful learning that has dominated the field during the past years. Many of the concepts studied in chemistry are abstract and are inexplicable without the use of analogies or models, so visualizations are here to stay and we think instructor’s use will be more as an educational methodology.

METHODOLOGY OF RESEARCH

We adopted a qualitative research in our study, applying a semi-structured interview to groups of pre-service chemistry teachers from a Chemistry Teaching Methodology II class from University of São Paulo (USP), São Paulo, Brazil. During this class these pupils had to prepare a mini-course to offer to secondary school pupils. This mini-course takes two days, and these graduates are responsible for the entire mini-course (subjects, methodology, assessments). At the end of these mini-courses we applied an interview to each group with several questions. The first set of questions (nine questions, common in both interviews) were more general and aim to know what conceptions they have about visualization and it's use, the next questions (three for the first group and four for the second group) were about their own choices of visualization to be used in their mini-course classes and one last common question about misconceptions.

According to Bogdan and Biklen (1994), the use of interviews is the best approaching tool to study people that share a particular feature. What they share between them will be revealed when they talk about their perspectives rather than when they are watched during their activities. Here we present the outcomes of the interviews made to two different groups of graduates. Each group was composed of 7 graduates that planned, presented and evaluated two lessons of secondary school pupils. The discourses' analysis was made with the contributions of Michel Foucault's theory of discourse.

RESULTS OF RESEARCH

As we mentioned before each group answered to a first set of questions with the purpose of finding what they think, understand about visualizations and its use in a general way. Here we have to point out that we use the term visualization in these interviews in the sense of the convention 2, a noun, something (visual) that was used for the graduates in the presented lessons.

First group: general questions

The first group chooses to plan a mini-course about a content of the secondary school curriculum 'Separation mixture methods'. On each question we are going to present the key ideas revealed by the group, so to the first question "Why do you decide to use visualizations in your mini-course?" The graduates answered that they were looking for something to start the lesson, in order to make an introduction with impact. They also said that they were searching for pupil's previous conceptions about this content, and visualizations seem to them a good way to help pupils to retrieve information. They also referred that the use of related images about the issue on discussion provides pupils with some information, but not all the information, forcing them to remember what they already knew about this content.

The second question was "What kind of visualizations do you use?" They said:- "2D statics images"-,- "Photos"-. The third question was "Why do you choose this kind of visualizations?" They answered: "Because of the simplicity", "Because, it was easy to build the sequence of transformations in each separation method." Related to what they said before, they only want to have some starting points with little information, nothing dynamic or too complex.

The fourth question was "The visualizations choice was engaged with some epistemological, ontological or axiological conception". To this question graduates showed same difficulty in understanding what was really asked. After some explanations about the meaning of these three terms the graduates said: -"No, we didn't think about that previously." They revealed that they were more concerned about the verbal discourse, the best image's sequence, than the images itself. They also referred that in respect to the values (axiological) they used "*good sense*" in order not to offend anybody, but they agreed for instance that in some images they showed some food brands. They said that the images were "clean" and for them they don't fell any effect when they watched these images and if it caused some impact on pupils it wasn't their intention, but once again they were more concerned with the sequence than with each image.

The next question was "Do you feel that the type and the quantity of visualizations used was suitable to your purposes?" They answered that there was some excess, and perhaps they should have changed a few images. They feel that it was one specific image that caused some confusion in pupils, and that they should have thought better on this choice. They also referred that even with some bad choices they achieved their goal (retrieve information using visualizations).

To the sixth question "The visualizations were there to illustrate or they hold information?" They answered that they hold some information. They wanted pupils to use the images as helping tools simultaneously with the verbal discourse to achieve the concepts of the content. Most of the images were related with the pupils quotidian, trying to keep their attention.

To the seventh question "Do you think that the use of visualizations must be framed with verbal information? Why?", They immediately answered -"Yes, and in a meaningful way". One graduate insisted on the idea that they should be complementary, and others mentioned that it was always necessary to have some kind of verbal information in order to guide the message that we pretend to pass. These graduates also referred that if there is a lack of framing between visualizations and verbal information it could create a conflict in the pupils' mind.

The eighth question was "Do you believe that the used visualizations helped the pupils' learning? What data do you use to answer this question?" The graduates answered -"Yes"- they mentioned that the images were used to contextualize the issue. One of them said – "the image made its role"- , and other said that in pupils' activities in class they used images a lot.

The ninth question was "Do you feel as teachers that the use of visualizations some how help your teacher's role. Why?" First they said that it helped to get their attention because they think that the more senses (audition, vision) they use, the more attention they get. One graduate said that maybe the visualizations make the teacher work less hard, others add that the visualizations make things "easier".

First group: specific questions

The next three questions are about their interventions and choices on the mini-course, so the tenth question was "On your mini-course when you approached the attainment of cooking salt you use one sequence of three images without any verbal discussion of the transformations between each image. What do you think that the pupils thought in that moment about those transformations? They answered that even they knew that probably some pupils may not know the right transformations, later when they discuss this they will have the opportunity of work in some misunderstandings or alternative conceptions.

The eleventh question was "During your mini-course one of you said to a pupil - "Ethanol is a molecule."-, without showing any visual element or any question with the intent to inquire if she knew the meaning of "molecule". What do you think that this pupil may have "imagined", or what kind of concepts she retrieved from her memory (if she already had something) in the moment that you introduce this abstract identity from the submicroscopic world of chemistry?

The answer was that even their perception was that the pupil didn't understand yet the molecule concept they felt that they should give a "scientific explanation". Later, they hope that someone could explain her better what a "molecule" is. They added that when they realize that she didn't know what a molecule is, one of the graduates tried to relate to quotidian's uses so at least she could identify this substance. After some group discussion about this intervention they agree that their lack of experience as teachers led them sometimes to have difficulties when they have to deal with unexpected situations.

The twelfth question was "On your mini-course sometimes you use the expression - "Are you seeing?"- applying to pupil's abstraction. How can you be sure that the pupil "saw" what you wish he had seen? They agreed that sometimes they "fall" in this situation, and when they realize (sometimes by the look in the pupil's face) that they weren't seeing anything, they try to make them externalize their thoughts in order to help them in a better way to achieve the concept.

The last question was again a general one "What consequences could arise from pupil's misconceptions on the teaching/learning process in chemistry?" Here the opinions were a little divided. Some graduates think that nothing is definitive, with time and good teachers the pupils will have the opportunity to correct these misconceptions, but others felt that these misconceptions could lead to great problems in future apprenticeships. They argue that all the concepts in chemistry are very connected, and there are some key concepts that compromise the apprenticeship of others. They believe that in some cases this lead to unmotivated pupils because they start by not being able to give meaning to the chemistry concepts.

Second group: general questions

The second group chooses to plan a mini-course about a content of the middle school curriculum 'Solutions and concentration'. As we mentioned before on each question we are going to present the key ideas revealed by the group, so to the first question "Why do you decide to use visualizations in your mini-course?" The graduates answered with several adjectives about visualizations, they said that they are: conspicuous, appellative, inducing. They also mentioned that both themselves and the pupils like visualizations and they are used to watch in their own classes as pupils. They felt that they should do something different. They want to get their attention, create interest and impact.

The second question was "What kind of visualizations do you use?" They answered: a video clip, a TV news (movie) and an animation, and with some hesitation one of the graduates added the red currant solutions that they show at the end of the first lesson as something concrete. The third question was "Why do you choose this kind of visualizations?" They answered that the pupils are used to see that kind of images. In order to explain salt dissolution they needed a dynamic visualization, so they choose one animation. They also said that they think that movement is very important; helps to get and keep pupil's attention.

The next question was "Do you feel that the type and the quantity of visualizations used was suitable to your purposes?" They answered that it was "nice", they felt happy with their own choices. The fifth question was "The visualizations choice was engaged with some epistemological, ontological or axiological conception". On this answer and like on the other group, graduates showed same difficulty in understanding what was really asked. After some explanations about the meaning of these three terms the graduates began to say yes, but their answers were not coherent, clearly they were talking about another perspective. They kept telling what they expected that visualizations could do, and even said that they thought in these issues; nevertheless they couldn't concretize any coherent answer.

To the sixth question "The visualizations were there to illustrate or they hold information? They answered that the video clip was illustrative, the news was "*to make them think*" and the others hold some information. To the seventh question "Do you think that the use of visualizations must be framed with verbal information? Why?" First the graduates answered -"No"- , - "Not necessarily"- , and then they said that they didn't think about that. Some hesitate and said -"Yes"- , a graduate said that if there is some verbal information (written) it could split pupil's attention. In the end the opinions' were divided, some of them said yes, but others still think that it was not necessary to have a framing.

The eighth question was "Do you believe that the used of visualizations helped the pupil's learning? What data do you use to answer this question?" The graduates said "Yes" and they reported only the animation. They said that they applied an inquiry to the pupils before the animation and other inquiry after they saw the animation, and they felt that the pupils have improved their knowledge about this issue. They said that the answers pos-animation were more coherent.

The ninth question was "Do you feel, as teachers, that the use of visualizations some how helps your teacher's role. Why?" They answered –"Yes, all the resources used were necessary." In the case of animation, they felt that it was completely necessary, without them it was very difficult for them to explain to pupils this process. They also added that the concrete red currant solutions they showed were very important, the pupils had the opportunity to make some reflection on something that belongs to their quotidian.

Second group: specific questions

The tenth question was "At the end of your second lesson one of you refers: We are going to present a video that shows what happens when we put salt on water". According to this introduction, what do you think that pupils thought about this phenomenon? First they didn't understand the question, after some explanations, one graduate said -"We didn't say that it was a representation!"-. Now, they all agree that it was a bad approach, and perhaps pupils thought that the animation was a "zoom" that a powerful camera did to the water. Nerveless, some graduates hesitated and said that this approach was not incorrect, it's expected that these pupils already know that in chemistry we always deal with models and representations and in some textbooks they also find this kind of language. These graduates even ask if it was productive to be always saying that we work with representations. They put the question – "The pupils pay attention when we say that this or that is a model?" They added – "We should discuss that they are representations, but it's not necessary to do this every lesson."

The eleventh question was "On the presented animation about salt dissolution, what do you think that pupils identified as the cubic structure of green and white balls? The graduates answered -"The salt"- and then they agreed that they still have a lot of difficulties to make a displacement to the pupil's thoughts and try to see their point of view. They hope that pupils didn't pay attention to the cubic structure.

The twelfth question was "On the same animation, what meaning do you think that pupils gave to the plus and minus signs that were on white and green balls, respectively? They answered that they don't know if they gave some meaning to that signs and that maybe they already know that they represent ions. If they never heard anything about ions, they believe that they just look at is as different kinds of atoms, and that one day they will have the opportunity to work on this concept and attribute some meaning to this observation. They also mentioned that wasn't the moment to discuss this concept and perhaps they pay more attention to the color of the balls than the signs. The thirteenth question was "Do you think pupils related in a correct way to the chemical symbols and the balls that were chosen for its representation?" They said that they didn't discuss this detail with them; they only tried to demonstrate with the animation what happens when you put salt on water.

The last question was again a general question "What consequences could arise from pupil's misconceptions on the teaching/learning process in chemistry? Some graduates answered that the pupils could carry these misconceptions for years compromising chemistry apprenticeship. Others said – "You fail the test." A graduate added that it depends on the importance of the concept, if it was a key concept such as atomic model, it could compromise all chemistry apprenticeship, if not the pupil will have the opportunity to clear up the misunderstandings. One other graduate admitted that it was just when he was preparing some classes that he had the opportunity to clear up some misconceptions, and this could be a serious problem, because sometimes teachers disseminate errors as instructors.

CONCLUSIONS AND DISCUSSION

Analyzing the outcomes of our interviews we can say that these pre-service teachers use visualizations as helping tools that they know by their own experience as pupils, that it can get pupils attention. It seems that they use visualizations mainly to run way from traditional class and second because of their educational value. Although they attributed cognitive value to visualizations, for instance, in order to make abstract concepts easier to understand, the first reason it's to make classes more pleasant.

When they are asked to explain their visualization's choices they show a weak theoretical knowledge about this issue, they aren't yet sensible to the impact of visualizations and they don't know how to use them in a fruitful way. It's clear on their answers that their visualization use is more concerned with the external effect that visualizations cause, than to the internal effects of visualization. They never mentioned the supposed role of (external) visualizations on internal visualizations (mental models) and it seems that they aren't really aware of visualization's *power*. We could say that they use visualizations in a *naive* form. This was very clear when they used the animation; first they never mentioned its use as a representation and second they don't discuss with pupils the codes and conventions associated to every visualization. They expected that like they said "*The images made their role*", and if everybody uses them, so they must be important for learning. They completely forgot that the intended purpose of the visualization and its relation to the referent is obvious for the teacher but sometimes is opaque to the novice pupils (Uttal & Doherty, 2008).

When asked about epistemological, ontological or axiological conceptions in visualization's use, they show some lack of knowledge in this area, even those who said "yes" to the question, like we mentioned before, their answers were not coherent and clearly they didn't think previously on these important questions. Once again on the answers to this question they show that they were more concerned with the verbal presentation, than with visualizations. They don't realize that each visualization convey a lot of information and values that sometimes are a little disguised but they are quickly assimilated by an interested pupil, and instructors must be always aware of these situations. These thoughts are very present when they said that some visualization was used only to illustrate or "to make them think".

A question that made some different opinions appear between the two groups was about the simultaneous use of verbal and visual displays of information. For one group it was clear that visual display must have always some verbal information in order to guide the pupil's perceptions, the other group had divided opinions but most of them said that verbal information was not necessary, in fact it could split pupil's attention. One graduate also said that this display of information should be complementary, but when asked to concretize a little more why, they weren't able to give a direct answer.

These sources differ in the fact that, textual information presents information in a linear sequence, whereas visual information sources provide all the information to the learner simultaneously (Thorndyke & Stasz, 1980; Larkin & Simon, 1987). When we have a textual display, the cognitive processing is directed by the structure of the text, but when we have visual display the processing of information is directed by the learner, so additional attentional processes for acquiring information from scientific visual information is needed (Gobert, 2007). Thus, teachers must be aware of these demands and find knowledge acquisition strategies for acquiring information from complex visualizations in chemistry.

When asked about if they felt that visualizations helped them as teachers and the pupils learning, they all said "yes" in both situations. For the pupils they based their opinions mostly on their perception of how pupils enjoy the images, nerveless one group mentioned that the inquiry that they applied after showing some visualization appears to have more coherent answers and then they attributed this improvement to the visualization use.

For them as teachers, they all said "yes" for several reasons: keep their attention, make "*things easier*", and make abstract things visible. And here we have to notice that one group of graduates almost shows a dependence of visualizations. On the animation's use the group felt that was completely necessary to use the animation. It was as if they didn't know how to explain this process without this visualization tool.

The answers to the questions about the specific choices that they did on their mini-course show us that there is a lack of training both in this area and as teachers. As pre-service teachers they show natural lack of experience, for instance, when they use the word molecule without knowing if the pupil had already internalize this concept, and when they realize that the pupil didn't know what was a molecule, they try to solve this problem giving an example.

Another difficulty that they show and feel it's when they try to see pupil's point of view. This fact is very evident in the answer to the last question; some graduates seem to have difficulties to make the necessary displacement to the pupils' minds. They based the answer on their own experience as pupils and if some how they could clear up some misconceptions, it's possible that other pupils could do too. They aren't yet taking in account the class pupil's diversity and the nature of chemistry concepts. On the other hand they also show a lack of theoretical background necessary for them to apply these new tools with some effectiveness in chemistry teaching. Like we mentioned before there is an absence of some knowledge related to the skills need to give meaning to any visualization.

First they don't show any particular understanding that it is necessary to improve *metavisual competence* on the pupils and that they must know previously the codes of representation, the conventions that underlie the visualizations, and second it seems that some of them begin to believe that visualizations could be a panacea for teaching some difficult scientific topics. We also believe that they don't see the visualization's use as a teaching methodology but just some helping tools that in punctual moments could give some help on chemistry teaching.

These findings reinforce our previous study (Ferreira & Arroio, 2009) where these graduates showed uncomfortable with these issues. In this work we concluded that their training course discusses these topics in some subjects but in superficial way. We also found that their conceptions are not solid, and sometimes even become misconceptions.

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"KITCHEN STORIES" - ASSERTIONS ABOUT FOOD AND COOKING AS A FRAMEWORK FOR TEACHING ARGUMENTATION

Erik Fooladi

Volda University College

Norway

ef@hivolda.no

ABSTRACT

The recent years have seen an increased interest in science education aimed towards the nature of science and inquiry. Within this context, promotion of reasoning and argumentation in school science has come forth as an important field of research. The present contribution is a work in progress aimed at involving pre-service teacher students in work towards development of a cross-curricular framework for teaching argumentation and inquiry. Herein the explicit teaching of Toulmin's argumentation pattern is utilised for students to analyse claims, expand them to build complete arguments and plan open-ended inquiry with regards to assertions (i.e. claims) about food and cooking collected from authentic sources in everyday life, herein termed "kitchen stories". Results from the pilot study indicate that students, starting from the claim, are able to construct complete argument patterns including all the elements given by Toulmin (claim, data, warrant, backing, rebuttal, qualifier), as well as to give suggestions to setups for experimental investigation of the kitchen stories. Possibilities and prospects are discussed of using kitchen stories for the teaching of argumentation and inquiry.

Keywords: *Argumentation, inquiry, open-ended, Toulmin, food, cooking, science, kitchen stories.*

INTRODUCTION

The present contribution describes a work in progress consisting of two parts. Firstly, an account is given promoting a novel framework for teaching argumentation and inquiry in cross-curricular settings, science being the major player. The second part describes a pilot project underway in which pre-service teacher students take part in the initial testing of this framework at University College level. It is argued that the present framework should be of relevance at a wide array of levels across education and research alike. As a byproduct of this, it is demonstrated how Toulmin's argumentation pattern may be applied in a new way in the analysis of assertions about food and cooking, what is herein termed "kitchen stories".

ARGUMENTATION IN SCIENCE EDUCATION

Within the international science education community and among policy makers it has been defined as a major challenge the development of quality teaching methods to promote scientific literacy, focussing not only on *what we know* but also on *how we know* and *why we do so* (e.g. Driver, Newton, & Osborne, 2000; Osborne & Millar, 1998; Rocard et al., 2007).

Consequently, the recent years have seen an increasing amount of research focussing on promotion of various cognitive skills in science education such as talking, reading and writing science (e.g. Wellington & Osborne, 2001) as well as the development of students' competencies in reasoning and argumentation (Driver et al., 2000; Duschl & Osborne, 2002; Erduran & Jiménez-Aleixandre, 2008; Osborne, Erduran, & Simon, 2004a). This emphasis has paved the path for new innovations in teaching for science literacy such as Keogh and Naylor's concept cartoon framework aimed at use in classrooms (Keogh & Naylor, 1999, 2000) and the IDEAS resource by Osborne et al. for promoting teachers' own qualifications in argumentation as well as facilitating pupils' learning of argumentation (Osborne, Erduran, & Simon, 2004b; Simon & Johnson, 2008). It has been advanced that teachers' own argumentation competency and skills are a prerequisite for quality argumentation to be appropriated in classroom discourse (Osborne et al., 2004a), and Simon et al. (2006) contend that within continuing professional development to promote argumentation in classrooms "[…] *it is teachers' initial understanding of argumentation that determines their development […]*" (p. 256). Furthermore, these and other researchers argue that *explicit* instruction of argumentation is necessary in order to efficiently facilitate higher-order thinking and argumentation strategies among teachers and pupils alike. Such explicit instruction might take the shape of teaching reasoning patterns in general (Zohar & Nemet, 2002), or the introduction of specific argumentation tools, such as Toulmin's argumentation pattern (TAP, see below) (e.g. Erduran, Simon, & Osborne, 2004; Osborne et al., 2004b; Simon et al., 2006). Accordingly, there is a need to develop a diverse range of teaching strategies and tools not only directed towards pupils, but also for the development of pre-service and in-service teachers' knowledge and skills in argumentation, in which we anticipate shall be able to carry out quality instruction. These strategies and tools should include an explicit treatment of argumentation and reasoning.

The Toulmin argumentation pattern (TAP) in science education

In research related to argumentation, Toulmin's argumentation pattern (Toulmin, 2003) has gained foothold as an efficient analytical tool for the education researcher in the study of argumentative student discourse (e.g. Erduran et al., 2004; Jimenez-Aleixandre, Rodriguez, & Duschl, 2000; Zohar & Nemet, 2002). In some cases TAP has also been utilised in the explicit teaching of argumentation, in shape of a tool for teachers to gain an increased understanding of discourse in their own classroom (Osborne et al., 2004a) or the epistemic nature of their own discipline (Simon et al., 2006), or introduced directly to the pupils as part of instruction on nature of science topics (Osborne et al., 2004b). In Osborne's (2004a) words: "*the use of these features of TAP offer teachers a richer metalanguage for talking about science and for understanding the nature of their own discipline*" (p. 1015). Therein, "these" are the detailed elements of Toulmin's pattern, as opposed to the composite, and thus simplified, terms "ideas" (claims) and "evidence" (data, warrants etc., see below). Hence, TAP allows for the instruction of argumentation in a way that explicates the rhetorical elements of an argument as it is commonly used in natural settings (Driver et al., 2000; Toulmin, 2003). The essential parts of an argument according to Toulmin's pattern are

Claim – the assertion put forth

Data – facts given in support of the claim

Warrants – provide the connection between data and claim

Backings – commonly agreed upon assumptions in support of the warrant

Qualifiers – special conditions under which the claim holds true

Rebuttals – statements that contradict either of the other elements

These elements may be drawn out in the shape of a visually clear and distinct flow chart-like manner (see below). Note that such a pattern does only offer analysis of *validity or coherence of arguments*. Questions about "correctness" or "truth" must hence be evaluated otherwise, such as whether the data put forward supporting the claim are true or not, or to what degree an expert opinion is credible or trustworthy. Also, each of the elements of a given TAP might be considered a claim in itself, and consequently one TAP might induce one or more new arguments. These facts bear direct relevance to the work herein, and will be discussed below.

"KITCHEN STORIES" - ASSERTIONS ABOUT FOOD AND COOKING

In the world of food and cooking, assertions about what to do, how to do it, and occasionally why to do so, are abundant, be it in first rate restaurants or in the everyday cooking at home. Within the branch of food science called Molecular gastronomy (e.g. Barham et al.; This, 2002; This, 2009; van der Linden, McClements, & Ubbink, 2007), also termed "science-based cooking" (Vega & Ubbink, 2008) or "evidence-based cooking" (Enserink, 2006), such assertions have gained attention as objects of study. By some, they have been termed "culinary precisions" and are collected for the sake of historic, cultural and culinary knowledge building, and for analysis of whether they are true or not (This, 2002, 2005, 2006). For educational purposes I suggest that "kitchen stories" might be a functional and sufficiently neutral term and will be used herein (the rather common term "kitchen myths" is avoided as it carries unwanted connotations, amongst them that myths are often not true). Kitchen stories are at the present being collected by the thousands in several countries, foremost in France (This, 2008), examples being "*mushrooms should not be washed, but only lightly brushed*" and "*sprinkle lemon juice on sliced apples or pears to avoid the fruit turning brown*". It has been suggested that kitchen stories might be categorised according to what might be termed "expected likelihood": 1) some stories seem wrong and they are wrong; 2) some seem wrong and they are true; 3) some seem true and they are wrong; 4) and some seem true and they are true, and finally 5) uncertain stories which fall outside the first four categories (see This (2005) for examples). However, I contend that these categories lack precision and are rather difficult to apply in a scientific framework, and there is therefore room for some alternative rationale for categorisation and analysis of these stories. From the viewpoint of argumentation theory, bearing in mind Toulmin's argumentation pattern, kitchen stories might be considered to be *claims*. Being product of tradition, tacit knowledge, everyday development and handing down from one person to another, only occasionally such claims carry justifications explaining why the advice should be followed. Even more seldom are the claims backed by empirical data, and consequently TAP might provide a heuristic for detailed exploration of kitchen stories. When dealing with such stories, several of the argumentative components might not be stated explicitly, or be missing altogether. Through the process of "building a TAP" from a given kitchen story, a clear picture of the argumentative strength of each assertion emerges. One example of such an analysis is given in Figure 1.

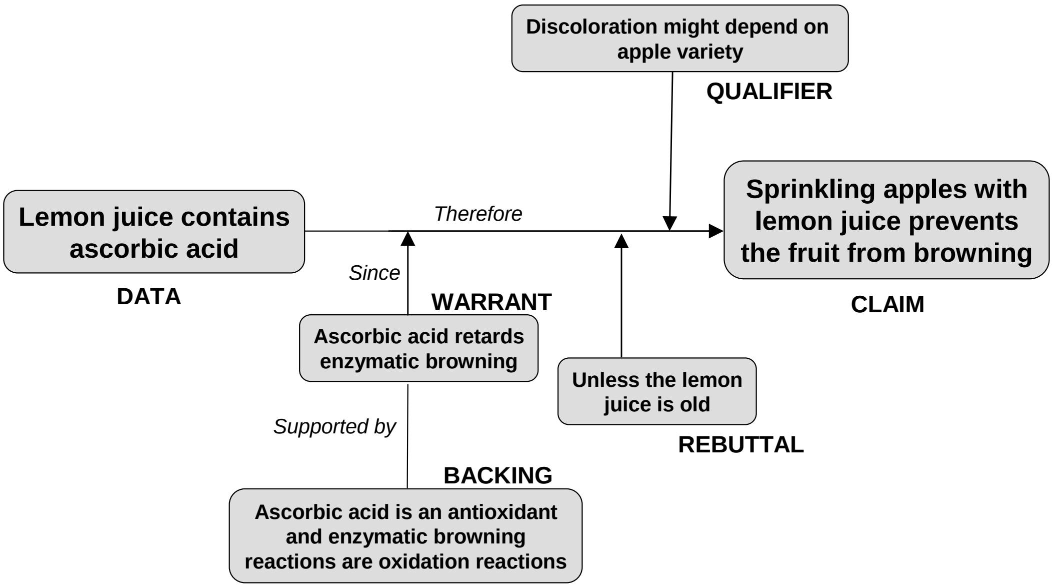

Figure 1. Example of TAP applied on a kitchen story about enzymatic browning processes. In this case, the TAP is completed, starting from only the claim, using inference and scientific content knowledge. Note that it is commonly possible to build more than one TAP from a given claim. The one shown here offers one example among several possible.

The project described herein seeks to integrate argumentation, in particular TAP, with kitchen stories to achieve a framework that can be utilised to promote understanding of concepts of evidence and argumentation, at the same time allowing for inquiry into authentic situations with relevance to everyday life.

PROMOTING ARGUMENTATION AND INQUIRY THROUGH ANALYSIS OF KITCHEN STORIES

Assertions concerning food and cooking, like the ones mentioned above, are firmly rooted in tradition and everyday life, and are familiar to most pupils, students, teachers and the general public alike. Due to the vast number of kitchen stories, this brings about a virtually inexhaustible source of potential inquiry projects. Also, kitchen stories are readily available for almost everyone to collect, given a cookbook, searching the internet, or interviewing primary sources such as family members, artisans or chefs. To my knowledge, the precedence for teaching argumentation, and TAP, is dominated by discussion of predefined questions, concerning either scientific or socio-scientific issues (e.g. Jimenez-Aleixandre et al., 2000; Kelly & Takao, 2002; Kolstø, 2006; von Aufschnaiter, Erduran, Osborne, & Simon, 2008; Zohar & Nemet, 2002). Kitchen stories afford an approach in which questions span between open-ended and fully guided. This might depend on various matters, such as whether the phenomenon in question is known to the teacher in prior, whether it is the teacher that chooses a predefined kitchen story or the pupils are given the task to go hunting for kitchen stories to explore and so forth.

The focus of the project described herein has hitherto been to involve pre-service teacher students in order to promote understanding of evidence and argumentation through the explicit instruction and use of TAP. 20-30 Norwegian students in food & health (a school subject closely related to home economics) and science classes attended a teaching sequence consisting of two units of each three weeks dealing with kitchen stories, argumentation and inquiry. The students were of mixed educational backgrounds and were at different points in the progress of their teacher education. They were organised in groups of 3-4 participants and group composition was as far as possible sought maintained throughout both units.

TEACHING PROGRAMME AND PRELIMINARY RESULTS

At the outset, the contents of the first unit were predetermined whereas the contents and focus of the second unit was left partially open. This way, it was possible to incorporate and utilise results and experiences acquired underway in the further development of the programme. The assignment was not subject to final examination, but formative assessment was given throughout the process in order to support the groups' progress.

FIRST UNIT – BUILDING VALID ARGUMENTS FROM KITCHEN STORIES

The unit was initiated by teaching sessions on argumentation in relation to the nature of science, citizenship and everyday life. The students were presented to TAP together with complementary teaching tools such as concept cartoons (Keogh & Naylor, 1999, 2000). They were allowed to practice the use of TAP on arguments and claims that had in prior been prepared by the lecturer, beginning with exercises on small, well defined problems, moving on to increasingly open-ended argumentative analyses. These preliminary tasks were done as group assignments with plenary summing up. This way, instruction was to model the use of TAP in a "controlled environment" so that all students should be able to reach a more or less definite conclusion on how to construct a complete TAP when starting from a claim. Following this teaching sequence, the groups were given a detailed prescription of which steps to take in order to solve the kitchen story assignment. It has been shown that careful structuring and modelling of the students' tasks is a prerequisite in order to support argumentation practice (Osborne et al., 2004a). Hence, a high level of detail was given in the assignment description, each step promoting skills in specific aspects of nature of science and argumentation. The students were asked to:

1. *Collect a number of kitchen stories from various authentic sources of their own choice (number equal to four stories per group member).*

   The sources emerging were various internet pages, cookbooks or personal communications (e.g. family members, friends or the students themselves)

2. *Among the collected stories select 3-4 which were to be scrutinised using TAP.*

   In this process, the groups had to make decisions about which assertions were more likely to end up as successful complete arguments as well as, at a later point, being verifiable in experimental inquiry (see below).

3. *Build a complete argumentation pattern including as many as possible, preferably all, the elements given by Toulmin.*

   The students were to expand from the claim resulting in a complete, albeit hypothetical, argument. A complete argument according to Toulmin's pattern might be valid, but still not "true" or "correct" in the sense that one or more of the elements might be faulty even though the argument itself holds. As a result, it was necessary for the students at a later point to test or challenge the various elements, and possibly revise the TAP according to scientific content knowledge or empirically derived information.

4. *Give some initial suggestions to how the kitchen stories under study might be tested experimentally.*

This part was given in order to prepare the students for the second phase in which some of the stories were to be tested empirically (i.e. in the case of sprinkling lemon juice on apples the students might suggest a comparison experiment subjecting apple slices to various conditions, such as vinegar, water, air, aqueous solution of pure ascorbic acid etc.).

5. *The results were to be documented as a written report containing information from all steps of the process.*

   Emphasis was given on students being able to justify choices and explicating their reasoning during the analyses. Furthermore, an extensive written response was given in order for the students to correct and refine their own work, since this was to be used as basis for phase two (described below).

The information at hand collected from this teaching process is not of sufficient quality to allow for a rigorous analysis of student responses and learning outcomes. However, some preliminary implications might be noted. Firstly, the students report that application of TAP on such authentic questions is a demanding task, but some groups were still able to successfully construct complete TAPs along with sensible suggestions to setups for experimental investigation. For a number of groups supervision was required in order to reach a complete and coherent TAP, and through this misconceptions concerning TAP or its elements could be identified. Examples of kitchen stories from the student assignments are (author's translations)

- *"Kiwis contain a compound that can dissolve jelly and is therefore not suitable in cakes and desserts that contain jelly"*
- *"Sprinkle the cutting board with water when cutting onions and you will avoid tears"*
- *"If you keep lettuce leaves in a bowl of cold water with ice cubes until the ice has melted the lettuce will become crisp and delicate"*
- *"Cooking carrots: the finer you chop the carrots before cooking, the more vitamin C will be lost"*
- *"For an extra light omelette, salt should be added after beating the eggs (rather than before)"*
- *"Bread and cakes stay fresh longer if you put an apple in the bread- or cake box"*

Secondly, in many of these analyses all the elements of TAP seemed to appear naturally as part of the process. This includes even rebuttals and qualifiers, the presence of which are often considered to represent argumentation at a higher and more demanding level (Erduran et al., 2004). One example of a TAP completed by the students is shown in Figure 2. From the figure it is worth noting how argumentation and science content knowledge are naturally integrated.

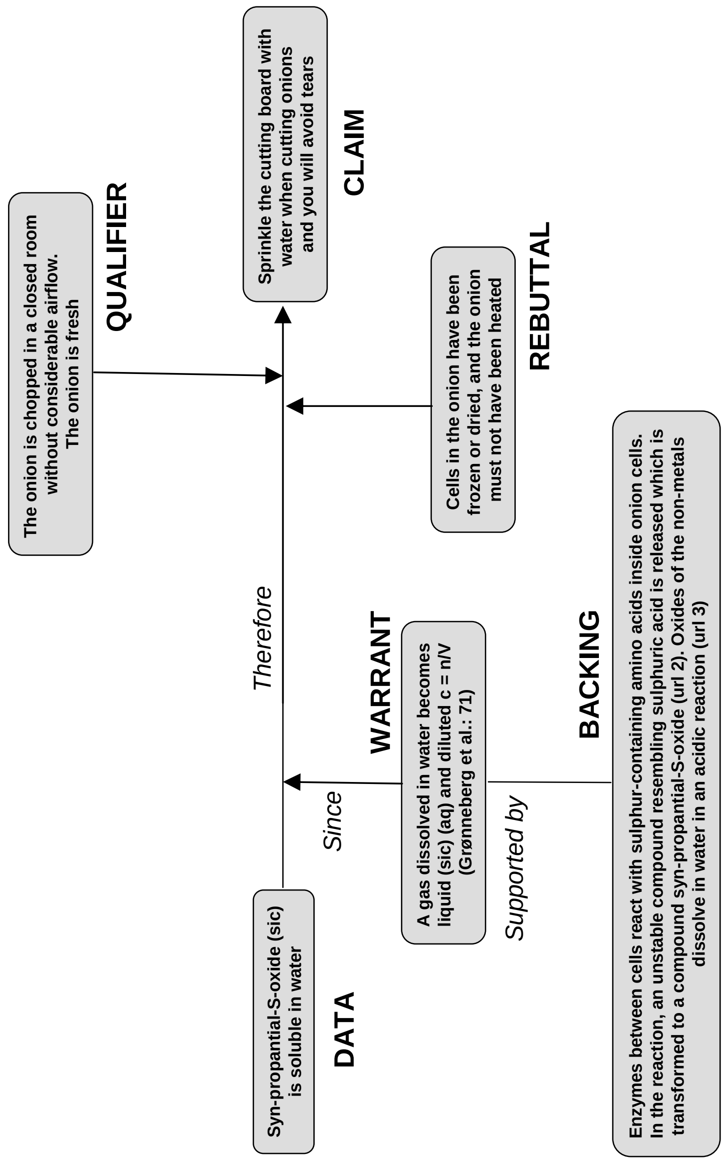

Figure 2. TAP constructed by students, starting from a kitchen story (claim). Author's translation.

Thirdly, in most cases it was necessary for the students to use appeal to authority-strategies (appeal to expert opinion) in order to complete the TAP and justify their scientific explanations (Walton, 2005). In doing this, a majority of the groups met problems in dealing with the epistemic status of various information sources. Examples include the use of commercial actors as sources for information:

"*[…] this is a source that has interest in being trustworthy*" (author's translation, students describing the web site of the Norwegian Egg Information Service)

"*It seems reasonable to believe that Coop has a certain justification for the assertions they publish on their web site since it is a trustworthy grocery chain*" (author's translation, students describing information from an "old wives' tales" page on the web site of the Coop supermarket chain)

Also, authority due to experience or craftsmanship emerged, such as

"*Assertion no. 7 is found in "The single person's cookbooks for absolute beginners". It is to assume that the authors of this book have good knowledge about cooking*" (author's translation)

This does not relate directly to the use of TAP, but rather to questions about truth or correctness (i.e. epistemological matters). A possible interpretation might be that the students hold domain specific, and contrasting, notions about source credibility between science and everyday life, as represented by the kitchen. The present information does not allow for drawing any conclusion on these matters, however, but represents an interesting lead to follow in future studies.

Hence, the main inferences that might drawn from this first part of the study is that, with varying degrees of scaffolding through supervision, (a) the students were able to build complete TAPs from a claim; (b) the students were able to give reasonable suggestions for experimental setups in order to investigate the claims (not described in detail herein); and (c) there was need for an increased emphasis on source evaluation. As a result, the following unit was designed so that the students had to explicitly discuss and justify their evaluation of the various information sources.

SECOND UNIT – EVALUATION OF SOURCE CREDIBILITY AND EXPERIMENTAL TESTING

This part was carried out the following semester, and the students were to build upon their first report as well as the detailed written response from the lecturer. This assignment was structured in a similar manner as the first phase, and the students were asked to:

1. *According to the lecturer's response, revise and re-evaluate the kitchen stories and TAPs from the first phase.*
2. *Carry out a critical evaluation of the various information sources and references used in the analysis, especially those used for justification purposes.*
3. *Make a justified choice of one or two among the analysed stories for experimental testing. Make a detailed plan for this testing based on a simplified version of the hypothetico-deductive method.*
4. *Carry out the experiment as planned.*
5. *Document the results in the shape of one experiment report for each kitchen story based on the IMRaD research paper format (Introduction | Methods and materials | Results | and | Discussion). Each report was to contain both the revised argumentation analysis of the story as well as a detailed source evaluation and an experimental account. In addition, one document was to be submitted containing the group's reflections concerning choices made, the work process and so forth.*

As part of the source evaluation, it is worth noting that there is a distinction between information sources used for kitchen stories (claim) and sources of factual information that are sought to fill the function of the other TAP elements. In the former, no emphasis is given to the trustworthiness or credibility of the source, whereas the epistemic status of the latter (data, warrant, backing, qualifier and rebuttal) is imperative.

DISCUSSION AND PROSPECTS

The framework described above consists of several elements, all of which are relevant to a nature of science-perspective in education. First and foremost, it is shown that kitchen stories provide for an entry point to teach argumentation. The topics covered by kitchen stories draw on both socio-scientific and subject-content matter and might provide a bridge between these two, rather than leaving one to choose between one or another which often seems to be the case (Osborne et al., 2004a). An explicit approach to teaching argumentation is achieved as students are forced to formulate the various TAP elements themselves in the process of building a valid argument. Furthermore, kitchen stories clearly invite the students to utilise all the elements in Toulmin's pattern; rebuttals and qualifiers emerge as natural elements when the claim is challenged. As an integral part, students need to evaluate the credibility and trustworthiness of various information sources, subsequently leading to the planning and carrying out of experiments.

Zohar and Nemet (2002) refer to previous research giving important factors in the explicit instruction of argumentation. These are shown to be a) knowledge about the structure and nomenclature of arguments and about the characteristics of a good argument; b) writing for enhancement of argumentation skills; c) teaching metacognitive knowledge about argumentation; and d) using authentic problems. The framework described herein will answer to at least three among these four characteristics, allowing for the application of TAP in a meaningful manner on authentic situations; a science teaching in which scientific enquiry is not only imitated by introduction of hypothetical problems but driven by real-life questions. Furthermore, von Aufschnaiter et al. (2008) reported that prior content knowledge, or experience, is *a prerequisite for* rather than a product of quality argumentation among pupils. Since kitchen stories might represent situations somewhere in between socio-scientific issues and scientific content knowledge they might provide opportunities for bridging the gap between scientific content knowledge and everyday issues (e.g. one needs to have a certain understanding of chemical reactions to be able to explain why the ascorbic acid in lemon juice prevents the apples from turning brown). This affords interesting possibilities for future research into the continuing study of the interrelationship between argumentation and scientific content knowledge. Subsequent to the argumentative exploration, experimental inquiry is introduced as a natural continuation. Lawson (2003) proposes that synergy effects might arise when inquiry (in shape of hypothetico-predictive argumentation concerning scientific concepts) and argumentation are linked. It might be contended that this is indeed the case when students study kitchen stories from the perspectives of argumentation and further plan and carry out experiments on order to test one's hypotheses concerning culinary claims.

However, school teachers might argue that involving pupils in collecting kitchen stories might pose a somewhat "risky business", since one cannot foresee the outcome and content knowledge covered by such a project. In such cases, the framework might include a few "ready-made" inquiry topics in order to model/scaffold how such a project might be accomplished, such as ascorbic acid in enzymatic browning, why one cannot make jelly with fresh kiwi or pineapple (degradation of gelatine by proteases from the fruit) and how this can be remedied, and so forth.

Future work within this project will aim at a more rigorous data collection in the use of kitchen stories for teacher education as well as exploring the potential for using this framework for other groups of students such as lower and upper secondary school, and possibly even primary school pupils. Indeed, Garcia-Mila and Andersen (2008) refer that children are shown to be able to justify claims as early as five years of age. Hence, the potential for kitchen stories as framework for such education purposes spans across almost every level of education, from lower primary school to university education. Even though food and cooking is a universal and essential aspect of life wherever humans exist, there should be cultural implications that need be addressed in order for the kitchen story framework to be applicable to education in diverse cultural contexts. Thus far, Scandinavian students have been the primary target, but it would be of great interest to expand this perspective to include a culturally more diverse range of students and pupils.

Finally, the field of argumentation (i.e. the use of TAP) might afford contributions of use even for molecular gastronomy as emerging scientific discipline, at least in the case of "culinary precisions" (kitchen stories) in which examples are emerging in the research literature (e.g. Dawson, Han, Cox, Black, & Simmons, 2007; Oruna-Concha, Methven, Blumenthal, Young, & Mottram, 2007; This, Meric, & Cazor, 2004). Hence, an intriguing perspective would arise if argumentation through science education could contribute towards knowledge building within the pure science, for once turning the perspective the opposite way around.

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SCIENCE TEACHERS' CONCEPTIONS OF DISTANCE EDUCATION: AN EXPLORATORY STUDY

Paulo Sérgio Garcia

Universidade de São Paulo, PhD Student.
Faculdade de Educação, Brasil

garciaps@usp.br

Vilmar Malacarne

Universidade Estadual do Oeste do Paraná,
Centro de Educação, Comunicação e Artes,
Brasil,

mala@unioeste.br

ABSTRACT

Studies on the teachers' conceptions of teaching and learning are not recent. The related results have been used, among other purposes, to help teacher education, itself. In Brazil, some studies on the teachers' conception of Distance Education (DE) have already been conducted, although they lack detailed information. This research, which is part of a larger research project conducted in several regions of Brazil, has the objective of investigating science teachers' conceptions of DE, both in the initial and continuing teacher's education. A case study was performed, in which questionnaires and interviews were used to collect data from 33 teachers in 18 towns of the State of Paraná. The results revealed that the teachers' conceptions varied from a range of negative characteristics to others connected with the need for DE. Four different groups of conceptions were identified: Distance Education as a Deceitful perspective, as a Useful resource, as a Possibility and as a Need. Regarding the initial teacher's education at distance, the rejection rate is higher than in relation to its application to the teacher's continuing education. The data presented herein may be used in teachers' education programs to make the teachers reflect and reconstruct their conceptions based on concrete information on the DE possibilities.

Keywords: *Distance Education, Teachers' conception, Science teachers.*

1. INTRODUCTION

Studies on the teachers' conceptions of teaching processes started in the early 70s, when many movements were initiated aiming to implement educational reforms.

Some authors described these conceptions as mental structures involving beliefs, concepts, meanings, mental images, etc., (Thompson, 1992), or as cognitive systems of beliefs and knowledge (Anderson, 1989).

The concept of science teaching, for example, was used by Hewson and Hewson (1989) to describe the teachers' ideas and interpretations used to take decisions about to the curricula.

The conceptions related to teachers' education have already been considerably investigated and studied (Roth, 1992) and according to Anderson (1989) the conceptions act as personal theories, which drive, among other things, the pedagogical practices of teachers. The author also says that teachers are responsible for rebuilding their own conceptions of teaching and learning through the course of their professional development.

In Brazil, the teachers' conceptions of DE have also been focused by recent studies. Recently, Garcia (2010) investigated the conceptions of a group of science teachers in a continuing education course at distance and Almeida (2007) analyzed a group of students (future teachers) in a Biology course investigating their interpretations of distance education. Both studies presented similar results, with a prevailing sense of mistrust and disbelief of DE with respect to course quality and the level of learning.

Also, Brazilian scholars have discredited the quality of distance education in Brazil, as witnessed by a fierce academic debate between those who do not accept the role of distance education in the initial education (Minto, 2009; Fétizon & Minto, 2007) and those who plead in favor of it (Litto, 2009; Sanchez, 2007; Cunha, 2006; Schlünzen, 2009).

The Ministry of Education (MEC), aware of this debate, has been implementing programs and projects of initial and continuing distance education. Public and private universities, education institutions, as well as certain groups linked to private education have launched programs and distance courses.

The DE expansion in Brazil reinforces the importance of studies on the teachers' conceptions of this modality of teaching. The resulting knowledge may be used in teachers' courses, even in those offered by MEC, providing the teachers with actual information on the possibilities of having quality distance education (recent national and international experiences, projects, quality programs), upon which they will be able to reconstruct their conceptions and enlarge their possibilities of professional development.

This study, which is part of a larger research study conducted in several regions of Brazil, has the objective of investigating in-depth science teachers' conceptions of distance education, both in the initial and continuing teacher's education, since these conceptions act as guidelines for decision-making in relation to their professional development.

BRAZILIAN EDUCATIONAL CONTEXT

In Brazil, the Ministry of Education is the body responsible for organizing and integrating the national education system of education. MEC, through its Secretariats, coordinates the policy guidelines for the organization, evaluation and teachers' education for both schooling levels, Basic Education (0-6 year-old; 7-14 year-old; 15-18 years-old) and Higher Education (Universities and Superior Education Institutes). However, the states and municipalities also establish guidelines and instructions for their specific education systems based on MEC policies.

In the last issue of the National Law of Guidelines and Foundations for Education (LDBEN/96), distance education was considered a modality of teaching that can be used in all national territories (Brasil, 1996). This law was ruled by some decrees: n.º 2.494, n.º 2.561 and n.º 5.622 (Brasil, 1998, 2005). These decrees detailed principally DE in terms of its working.

In Brazil there currently exists 257 Institutes of Education, including universities, authorized to offer courses in higher education, with 1181 courses in various areas and in different levels of education (Sanchez, 2008). In higher education, from 2004 to 2007 over 400 courses have been added. In terms of students' enrollment in these courses, there were 59.611 in 2004, and in 2007 it was almost 369766 (Mec/Inep, 2007).

The MEC is promoting some public policies to increase the equitable access to higher education Institutions by teachers. In order to do this, it created the Secretaria de Educação a Distância (Seed), the UniRede (network of public university system), the Universidade Aberta do Brasil (Open University), and some other projects to promote teachers' education, such as: Proformação and the Pró-Licenciatura.

Distance education has been an alternative well used by MEC to teachers' education in general, and to science teachers' education in particular. MEC insists that distance education could be a method for improving access to higher education.

DISTANCE EDUCATION AND TEACHERS' CONCEPTIONS

The teachers' ideas and conceptions in general and those linked to teaching and learning in particular, influence and guide their decisions on the pedagogical practices they elect (Anderson, 1989), and, we may also say, their professional development, since the learning act is deeply affected by preexisting knowledge and beliefs.

Teachers' conceptions may be seen, in a broader sense, as mental structures, which involve beliefs, preferences, concepts, propositions, rules, meanings, knowledge and mental images, among other things (Thompson, 1992). According to Anderson (1989) conceptions are cognitive systems of beliefs and interconnected knowledge that influence perceptions and reasoning.

Therefore, studies of the teachers' conceptions relate to the understanding of their values, motivations, thoughts, prejudices, knowledge, etc., which affect their pedagogical practices and their motivation to learn through DE.

Teachers' conceptions are affected (though not only) by: a) the social context (the conception of education, teacher's position in the society), b) the educational context (teaching theories, personal perceptions on students, parents, principals, methodologies, evaluations, education level), c) the political context (laws, curriculum, educational system values). The teachers' education, initial and continuing, as well as their political and ideological positions, also acts on their conceptions.

In the decade of 1970, studies started to approach the teachers' conceptions of education. In the field of science teaching, for example, Hewson and Hewson (1989) used the science teaching conception to represent the ideas and interpretations teachers used when making decisions related to the curricula.

Studies on these conceptions became more and more important for teacher's education (Roth, 1992), since, according to Anderson (1989), the conceptions work as personal theories which guide the pedagogical practice.

Recent studies in Brazil have attempted to understand the teachers' conceptions of DE. Garcia (2010), analyzing a group of science teachers' who attended a course of continuing education at distance, revealed that many of the professionals at the beginning of the course displayed negative feelings and mistrust towards this type of course; however, as they became familiarized with the DE processes, the negative ideas were replaced by more positive feelings.

In a research intended to analyze the conceptions of future Biology teachers in relation to distance education, Almeida (2007) said that the concerns of most students relate to the validity of the courses, the view of the job market on these professionals and the level of learning. The author also said that even those students, who recognized the DE courses capacity of narrowing borders, did not unreservedly trust this modality of teaching.

Many of the participants in this research said that they would not enroll in a Biology course at distance, due to the lack of practical and laboratory classes, which they understand as essential. However, when the process was explained, many of these students changed their position. This shows that the knowledge of the distance education processes may interfere on the teachers' view of this modality of teaching.

Although these studies have revealed a certain mistrust of teachers in relation to DE, they also showed that the most of the prejudice against these courses is based on the lack of knowledge and familiarity with the methodologies used in distance education.

Such discredit is also shared by many researchers, who do not rely on the quality of distance education courses. With respect of the teachers' initial education, opinions are polarized in two groups. On one hand, those who do not accept the inclusion of distance courses in the initial education pointing out their negative characteristics, superficiality, fragmentation of the teaching process and precariousness of teachers' work (Minto, 2009). Others, in favor of attendance courses, criticize the inadequacy of the legislation regarding DE and do not agree with its use as a public policy of teachers' education (Fétizon & Minto, 2007). On the other hand, there are researchers who understand that distance education offers great contribution, compensating for the lack of universities in Brazil and helping many students with special needs (14% in Brazil). Others recognize the importance of distance education courses in the democratization of the access to higher education (Sanchez, 2007) and to supply the lack of qualified teachers (Cunha, 2006; Schlünzen, 2009).

The Ministry of Education, aware of the debate about the general sense of mistrust regarding distance education, continues to expand its policies related to the teachers' initial and continuing education, attempting to facilitate the access to higher education. Public and private universities, as well as private groups and even schools are already launching distance education programs and courses. Within this expansion of DE courses, studies on the teachers' conceptions gain importance, either to demystify or to improve this teaching system.

2. METHODOLOGY

This study is part of a larger research project conducted in several regions of Brazil. The overarching research question being addressed is: What are science teachers' conceptions of distance education in Brazil, both in the initial and continuing teacher's education?

In order to investigate science teachers' conception of distance education two study cases were carried out in two regions of Brazil. One of the regions "Grande ABC Paulista" includes 6 towns (southwest), a major industrial and business area in São Paulo metropolitan area. The other region includes 18 towns around Cascavel (state of Paraná), in the middle of a rich rural area in southern Brazil. Both areas present leading indicators both social and economic. In this study, we present the data from the southern of Brazil.

This sample of participants was obtained where the researcher had access to schools, and where science teachers were, effectively, being affected by distance education courses. The sample has, at least, one participant of all 18 towns, and these science teachers were chosen randomly from 54 high schools.

In this region are nearly 300 science teachers working in these Elementary and Secondary schools; both quantitative and qualitative data was collected from 33 teachers participating in the study.

Data from the quantitative methods using a Likert Scale, has not been completely analyzed. In this study, we present only the data from qualitative data collection methods.

Qualitative research interprets information in a broad way, within the context where the research subject is located, involving the collection of predominantly descriptive data, and highlighting the process more than the product and showing the investigational subjects' perspective rather than the researchers'. (Ludke & André, 1986).

The line of qualitative research is bound to the interpretation of environments, considering that every environment, the place where people live and interact, is surrounded of meanings and senses. It is through such interactions that people build up their realities, through experiences that are highly valued by the qualitative focus.

According to Ponte (1992) studies on teachers' conceptions clearly have limitations related to the methodologies used, since many teachers do not feel comfortable to participate in this type of research. He suggests the use of interviews rather than direct questions, observations and document analysis. All these data must be crossed carefully in order to find out the conceptions. This study used a combination of two research techniques: interviews and questionnaires.

An interview with a pre-defined script was conducted with 10 teachers and questionnaires were answered by other 23 teachers. More interviews were discontinued because saturation of the date made further collection unnecessary. Freire Junior (2005) cites that saturation occurs when the researcher, after a certain number of interviews, realizes that the data explain the object of research on their similarities and differences. Thus, data from interviews do not bring newer information to that already acquired.

The interview was composed of questions about participant profile (gender, age, marital status, level of education, working hours per week, experiences with technologies and distance education), and about teachers' conceptions regarding the DE: how they understand DE, what is the level of Brazilian education they consider DE more appropriated; how they see DE contribution to science teachers' education, and how they distinguish the relationship between DE and conventional education.

The data obtained in the interviews served as the basis for constructing the questionnaire.

The questionnaires consisted of questions on the participant profile: gender, age, marital status, level of education, etc.. The open-ended questions in the survey related to the teachers' conceptions of DE, distributed into 4 categories: 1) understanding DE; 2) DE suitability; 3) contribution of DE to science teachers' education, and; 4) relationship between DE and conventional education.

The first category describes the teachers' conceptions of distance education. The second explains in which level of education in Brazil DE is considered to be more appropriate. The third focuses on how the teachers view the contribution of DE to education, and the fourth portrays the relationship between distance and conventional education.

3. FINDINGS

The results are presented and discussed according to the categories previously defined.

Positioning Distance Education.

The teachers' participants placed distance education within a spectrum that goes from negative characteristics to features associated with the need for this kind of courses. Four groups were identified, based on their conceptions of DE:

1) Teachers who associate DE with a "Deceitful" perspective;
2) Teachers who see DE as "Useful";
3) Teachers who link their conception of DE to a "Possibility of access"; and
4) Teachers who place DE as a "Need".

Teachers of the first group, who see DE as deceitful (12,1%) said that these courses provide a certificate without accomplishment of learning, a weak form of learning when compared to attendance courses and the illusory idea that DE compensates for the lack of schools.

Teachers who related DE to usefulness (36,4%) see this type of courses as useful for the teachers' continuing education, since they can be used to deepen the knowledge already acquired and may be advantageous when taken with seriousness and dedication. However, these teachers also said that distance education cannot replace conventional education and is unsuitable for initial education when the student is not yet able to study by himself.

1.1.1. Those who associated the conception of DE to the possibility of access (42,4%) said that these courses may be a solution for students who do not have time or conditions to physically go to school or universities. They also said that many people may benefit from DE and have their work possibilities enlarged, but only when the courses are seriously faced. In their opinion, education at distance does not replace conventional attendance courses and should not be used to provide graduation certificates, because students at this level lack the required maturity.

1.1.2. At last, the fourth group of students related DE to a need (9,1%) due to the high demand for knowledge (schools or universities do not meet this demand) and the needs of those who could not attend conventional courses. They understand DE as an essential modality since it reaches worldwide levels.

1.1.3. Even the teachers who approve distance education, either as a useful resource, a possibility of access or a need, agree that this form of education does not replace conventional courses, it is not suitable for initial education and ought to be treated with seriousness.

Suitability of Distance education

Regarding the suitability level of distance education, the teachers' participants said that: a) it is suitable for continuing, but not for initial education; b) it depends on the course and the institution; c) it is not suitable for initial, neither for continuing education; and d) it is suitable for both stages of teachers' education.

Of these teachers, 69,7% said that distance education is suitable for continuing, but not for initial education, based on the following justifications: a) nothing replaces attendance classes, mainly when it comes to didactic and methodological subjects, or laboratory classes; b) distance education does not supply the students' initial needs; c) initial education requires previous knowledge; d) subjects of teachers' initial education are complex; e) the teacher needs a solid pedagogical basis; f) exchange of knowledge/experiences is critical for a satisfactory learning level; g) commencements are usually turbulent; and h) personal contact with a teacher is important for the learning process. On the other hand, in relation to the continuing education, these teachers commented that: a) distance education may be seen as another option; b) it supplements good professionals' natural search, as long as these professionals have attended traditional initial education, and c) distance courses must be constantly evaluated.

Another group of teachers (6,1%) said that the suitability of distance education courses depends mainly on the institution and on the resources used.

Also, in the opinion of 18,2% of the teachers, DE is not suitable for initial and neither for continuing education because of the lonely conditions to study and solve problems, lack of intermediation of a teacher and lack of interaction. They also point out the difficulty to form good teachers even at attendance courses and the importance of a supportive teacher for the students. One of the participants commented how unacceptable it would be a distance education course to form surgeons.

At last, 6% of the teachers agreed with the idea of DE for initial and continuing education as well, since it would help many people who could not initiate their major courses.

Contribution of distance education to the teachers' development
With respect to the contribution of distance education to the teachers' development, particularly science teachers, the respondents were classified into three groups: a) yes, DE does contribute to the teachers' education; b) DE provides little contribution; and c) it depends.

Most of the teachers (84,8%) said that distance education can contribute to their development by providing, for example, refreshing courses, in-depth supplementary courses, exchange of experiences with professionals from other regions, access to knowledge. Some teachers added that this contribution depends on the teacher's maturity, participation and dedication level, and that it is important to have attended a traditional initial education which ensures certain required knowledge.

For the other group (9,1%), distance education can provide little contribution to their development, since these courses do not fully meet the needs and still present some restrictions. A smaller number of teachers (6,1%) said that the contribution depends on the seriousness of the course and the teacher's participation.

Relationship between attendance and distance courses in the teachers' education
Almost the whole group (84,8%) think that the existence of distance education courses does not represent a threat to attendance courses. For 15,2% of the teachers, conventional attendance courses will be someday replaced by distance education courses.

4. ANALYSIS AND IMPLICATIONS

The data obtained presents the science teachers' conceptions of distance education and aspects related to the contribution of this modality to the initial and continuing teachers' education.

The conceptions varied from negative characteristics to the need for distance education. Four broad groups of conceptions were identified: DE as a deceitful resource, as useful, as a possibility of access and as a need.

It is worth mentioning that even for those teachers who associated DE with usefulness, possibility of access or need, education at distance does not replace traditional education, and ought to be seriously treated.

Furthermore, teachers said that DE is indicated as a possibility for those that do not have time to attend traditional school (or college), or as a way to provide access for those that are away from the universities.

Teachers also said that DE is necessary for those that could not study in traditional courses. It means that these professionals considered DE as a possibility of access or as a need for those that were excluded of traditional education.

Most of the teachers surveyed do not consider DE suitable at the initial education, but tend to be more receptive in relation to DE for continuing education. And here again, the seriousness of the courses offered was emphasized.

Teachers' conceptions are more in line with those of the researchers who are against distance education courses at the teachers' initial education (Fétizon & Minto, 2007; Minto, 2009).

Part of these conceptions, according to Gomes (2007) is based on the fact that distance education courses, in many regions of Brazil, are seen as second-class education or as a manner to regularize the situations of individuals who could not attend traditional education.

The prejudice against distance education arises, many times, from the apparent lack of effort to obtain the certificates, lack of commitment from students, insufficient learning, lack of seriousness in the courses offered, etc.. However, the prejudice is also supported by the lack of knowledge on the current possibilities offered by distance education, and its association with, for example, dressmaking or electronics technical courses and supplementary fundamental education courses, which were generally offered by mail in the past.

Another reason for the disbelief that surrounds the distance education courses is the fact that many of them are offered and monitored by the government, with questionable quality.

The present study enlarges the results found by Garcia (2010) and Almeida (2007) and provides a deeper understanding on the subject, which could be used in the continuing education programs for science teachers.

As from this understanding and based on recent national and international experiences, projects and programs, the teachers may be led to think over and reconstruct their conceptions. They can compare their conceptions with concrete information on the possibilities of having distance education with quality.

Besides, experiences may be organized in order to make the teachers more familiarized with this type of courses and change their conceptions, since distance education offers many possibilities of professional development.

Guedes, Mehlecke and Costa (2008) also suggest the need for more courses of continuing education through the use of new technologies, with the purpose of involving the professionals and making them more aware of the processes and benefits of distance education.

Ultimately, the teachers' conceptions presented in this study hinder the teachers' development, to the extent that they do not feel motivated by DE. Since learning is closely linked to motivation, their conceptions end up adversely affecting their professional development.

The new data analysis, we will perform in the following months from southwest of Brazil, will allow us to better understand science teachers' conceptions of distance education. However, considering the results presented here, we can say that there are at least five direct implications related to the Brazil' Ministry of Education. As from these data the MEC can launch a national program, as part of public policies to: 1) demystify DE to teachers, 2) inform and aware teachers about the possibilities and benefits of distance education, 3) improve DE processes and methods, 4) improve the monitoring processes of distance education courses, 5) initiate projects to better familiarize teachers to DE processes.

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STUDENTS' UNDERSTANDING OF MODELS IN TEXTBOOKS

Niklas Gericke

Karlstad University

niklas.gericke@kau.se

Mariana Hagberg

Karlstad University

mariana.hagberg@kau.se

ABSTRACT

In this study 18 to 19 years old upper secondary students' ability to discern the use of multiple models in genetics when reading content specific excerpts in Biology textbooks are investigated. Two excerpts using different models when describing gene function was selected from authentic textbooks and nine students were given the specific task of reading the excerpts. Afterwards the students participated in semi-structured interviews. The main theme of the interview was about how the students experienced the similarities and differences between the texts, and how they understood models and conceptual change in genetics. Students recognized the existence of multiple models in a general way, but had difficulties discerning the different models and the conceptual change that occurs between them in the texts. Students had difficulties in transforming their general knowledge about multiple models into understanding of content specific models of gene function in the textbooks. These findings may have implications for students' understanding of conceptual knowledge since research has established textbooks as one of the most influential aspects in the planning and execution of biology lessons.

Keywords: *Genetics, Models, Students' understanding, Textbooks*

BACKGROUND

Models and their importance in teaching science have been the object for extensive research in science education during last decades (Gilbert & Boulter, 2000; Grosslight, Unger, Jay & Smith 1991; Halloun 2004). In teaching genetics the use of models and modelling has been emphasized as an important aspect in improving students' conceptual understanding (Finkel & Stewart, 1994; Thomson & Stewart, 2003). The use of models is also regarded as a vital component in many steering documents. The national Swedish curricula for the science program (grade 10-12) in upper secondary school states that: 'Thinking in terms of models is central to all the natural sciences' (The Swedish National Agency for Education, 2009, p. 35). Similar claims can be made on the basis of the American Association for the Advancement of Science guidelines (1990, 1993). The benchmarks from AAAS (1993) state for students in grades 9 through 12: 'The main goal should be getting students to learn how to create and use models in many different contexts' (p. 270).

Models play a central role in the outcomes of science (Giere, 1988). There is no unique definition to the term *model* in the literature, and there is no consensus of the use of the term, be it philosophers of science or science educators (Halloun, 2004). In this paper, a model in science is seen as a representation of a phenomenon initially produced for a specific purpose. The model is a simplification of the phenomenon intended to be used to develop further explanations of the phenomenon. Moreover models also play an important role in communicating science. Through comparison and testing, a model may reach agreement among scientists and become what is called a scientific model (Gilbert, Boulter & Rutherford, 1998). The development of different scientific models over time, representing the same phenomenon, has led to the occurrence of so called multiple models, see Figure 1. In school multiple models are often used implicitly to describe a specific phenomenon. For example the billiard ball model, Bohrs' planetary model and the electron cloud model are all used to represent the atom in upper secondary school.

The problem of fitting different gene concepts together is well known from the philosophy of genetics (Beurton, Falk, & Rheinberger, 2000; Gerstein et al., 2007; Portin 1994), which has led to the development of different explanatory models depending on: which aspects of the genetics that were studied; which technological devices were at hand; which model organisms that were used etc. Therefore the historically developed concepts in genetics belong to different scientific frameworks although the same term might be used. In a previous study (Gericke and Hagberg, 2009) it was found that multiple models were used as representations of gene function in school textbooks. Moreover it was shown that these models were used in an explicit way without reference to the fact that the textbooks frequently shifted from one model to another. In this study we wanted to find out how the students interpret and understand this implicit use of representations in their own textbooks.

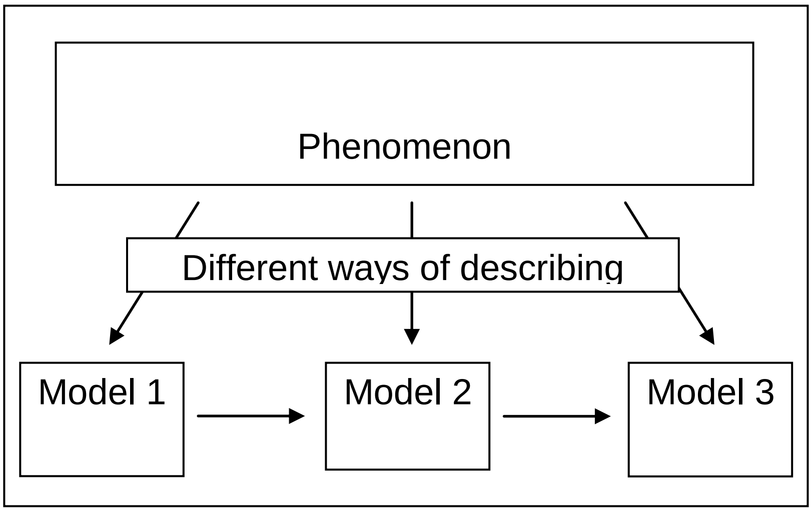

Figure 1. A phenomenon can be represented by multiple models.

Learning to use scientific models is challenging for students and is closely intertwined with the problem of conceptual change. Without conceptual change in how different models are understood, students will misunderstand and misuse the models they are learning (Chinn and Samarapungavan, 2008). It could be expected that students may have difficulties in understanding the conceptual knowledge where there is a variation in the description of the same phenomenon by using different models. In school textbooks the students themselves must discover the different multiple models found in them, since textbooks do not explicitly deal with the occurrence of models in science (Gericke and Drechsler 2006; Harrison, 2001).

In this study18 to19 years old students attending the science program (grade 11 and 12) at upper secondary school in Sweden were investigated. The students' ability to discern the variation and use of multiple models of gene function when reading content specific excerpts in biology textbooks is investigated.

The research questions that guided the study were:

- How do 18 to 19 years old upper secondary students in the domain of genetics understand the use of multiple models, and the conceptual change that occurs between models, in biology textbooks?

METHOD

Design

Nine students, all 18-19 years old and attending the science program (grade 11 and 12) in upper secondary school in Sweden participated in this interview study. Hence these students represent that cohort of students in Sweden that take the most advanced courses in biology and chemistry at the upper secondary school.

The students have actively chosen to participate in the study. According to their teachers the students represent an average of achievers of this cohort of students. In order to ensure that the students were average achievers they were sampled from a larger cohort by using a questionnaire instrument, which probed students understanding of models. Average students were asked to participate in the study. The students come from two schools in two different towns. Before volunteering they were given detailed information about the study. The students were first given the assignment to read two texts at home until a specific occasion when they were interviewed. The students were told to put in as much effort to their reading as they regularly do when getting homework/tasks in school. It would have been possible to use any of the available biology textbooks in Sweden, but these textbooks were choose since the schools participating in the study used these books in their biology courses.

The texts were in a previous study classified by the researcher as being representative to two different models describing gene function (Gericke and Hagberg, 2009). Text 1 represents a classical model and text 2 a neoclassical model. Here follows a description of the two texts:

Text 1: The headline for text 1 (Henriksson 2007a, pp. 40-51) is *Genes are inherited,* and the text describes Mendelian inheritance among plants and animals with classical examples from peas and fruit flies. A strong connection is drawn to the chromosome, but DNA is mentioned as the base for a gene. The text includes several genetic crosses with pictures visualizing a phenomenological level of how the genotype contributes to the phenotype. The text is situated in a framework of classical genetics and a historical reference is made to the scientist Hunt Morgan's fruit fly experiments. The text represents a **classical model** of gene function. In such a model the gene is viewed as a particle unit on the chromosome which defines a characteristic or a trait at a phenomenological level. The explanations in the model are causal and idealistic only describing relations. Explanations on a macro level are extrapolated to the cellular level and the gene is defined by a top down approach. The classical model is thoroughly outlined in Gericke and Hagberg (2007).

Text 2: The headline for text 2 (Henriksson 2007b, pp. 32-36) is *Nucleic acids*, and the text describes how DNA is built up, the genetic code, mRNA and protein synthesis. The description is at the molecular level but also at the cellular level. The text includes several illustrations of biochemical processes such as replication, translation and splicing. A short passage of the text refers to the historical findings of the structure of the DNA-molecule by Watson and Crick. The text represents a **neoclassical model** of gene function. In such a model the gene is defined as a stretch of DNA which defines the polypeptide or protein it produces. The explanations of the model are given on the molecular- or cellular level and try to describe as naturalistic as possible the biochemical processes that take place in this production. The model uses a bottom up perspective and gives a deterministic view of the gene. The neoclassical model is thoroughly outlined in Gericke and Hagberg (2007).

Interviews

A semi structured interview was designed according to Kvale (1996). An interview guide was constructed. The three main themes of the interview was about how the students:

- Experience the similarities and differences between the texts
- Understand models and conceptual change in genetics
- Understand models and conceptual change in general

All questions were asked in relation to how they appear in textbooks. The textbooks were on hand in the interviews and the excerpts were used as a starting point for various questions. A interview was conducted with each of the nine students, lasting about 45 minutes.

The interview consisted of three distinct phases: the briefing and warm-up phase at the beginning, the main phase, and the debriefing phase at the end. During the main phase the themes stated above were discussed. The main phase of the interviews was recorded and transcribed in full. After transcription the second researcher once again listened to the tapes and proof-read the transcripts.

Student transcripts were coded according to the students related to: differences/similarities between the texts; models and conceptual change in genetics, models and conceptual change in general. A matrix was constructed in which the coded answers were transferred and correlated to the different themes. In that way we could describe what was characteristic for the students' ideas about each theme. The development of the matrix was discussed between the researchers so that inter-coder agreement was obtained.

RESULTS

What are the differences between the texts?

Most of the students experienced the differences more than the similarities between the two texts' descriptions of the gene function. One of the students who thought the texts portrayed more or less the same model assigned the differences between the two texts to a matter of for example disposition or layout, i.e. non-content explanations (see category 1 in Figure 2). When characterizing what the differences in the description of gene function consisted of, usually a dichotomy between the two texts was mentioned (see Figure 2). Several of the students claimed that one text was more thorough and detailed in the description then the other (see category 2 in Figure 2). Two of the interviewees (S1 and S2) explicitly stated that the texts portrayed the same model. Differences between the texts were referred to the possibility to explain with various depths:

> S2 – Yes the texts have different depths of their descriptions. (Classified as category 2 in figure 2)

Otherwise comments were made about specific content dichotomies between the texts such as macro/micro level; traits/DNA; gene structure/ gene function etc. (see category 3-8 in Figure 2). Four students could reinforce their statement about the differences with several claims, but most often only a short explanation was given as exemplified of the following citation:

> S8 - I thought that this [text 1] described more how genes control the heritage, more what you will look like and so. This [text 2] described more how the genes work. (Classified as category 4 in Figure 2)

1. Non content explanations (e.g. disposition, layout, difficult to understand)
2. Explanations are more simple or easy / explanations are more complicated or detailed
3. Explanations on macro level / explanations on micro (cell- or molecular-) level
4. Explanations about heredity / explanations about how the gene works
5. Explanations about chromosomes / explanations about protein production
6. Explanations about traits / explanations about DNA
7. Explanations about gene structure / explanations about gene function
8. Explanations about the importance of the environment / explanations excluding the importance of the environment

Figure 2. Categories of student answers to what differ between the two texts.

To elucidate this question further we asked the students why they believed genetics was described in two separate chapters in two books instead of in a single chapter. The idea was to find out if the students could refer to the fact that the two texts depict two different scientific frameworks, classical genetics and molecular genetics. All the students in the interviews recognized that both texts were dealing with genetics. Five of the students (S4, S5, and S7-S9) gave similar content related reason, as stated in the question about the differences between the texts, to why the authors divided genetics into two chapters. For example S8 said:

> S8 - Perhaps it has to do with the fact that they [the texts] deal with very different things. The first [text 2] is about how genes function and the second [text 1] how the genes affect our appearance. These are actually quite different things.

The other students' answers to this question (S1, S2, S3 and S6) were non-content explanations such as layout- and disposition reasons.

> S6 - you understand more fully if it is structured properly. I would almost think it just as easily could be presented in one text.

Hence S3 and S6 gave different answers to these two questions indicating it being difficult for students realizing that the historical development and structure of scientific knowledge may be an important tool for structuring the content of textbooks.

The conceptual incoherence between the two texts

The conceptual change that occurs between the two models portrayed in the different texts leads to conceptual incoherence, and to find out if and how the students looked upon these contradictions between the texts they were asked accordingly. We did not use the term incoherence, instead we discussed whether the students could recognize any contradictions or conflicts between the content in the two texts. All the interviewed students except S7 did not recognize any contradictions or conflicts between the content in the two texts, which is remarkable since we in the interviews explicitly showed the students different descriptions in the texts. For example in a question about different descriptions of the gene in the texts S9 says the following:

> S9 - I do not think the descriptions contradict each other, they really say the same thing, and it depends on how you interpret. A bit of a DNA molecule ... DNA is the chromosome when it is folded, so really it is the same thing, just told with different words.

Student S7 was able to recognize that the structural description of the gene differed in the texts after some discussions:

> S7 – Yes, how these segments that create proteins works. It might not be just that part of the DNA, but it might be several pieces of the string of DNA that code for a certain protein. Then the gene would be scattered over several locations.

To clarify these important aspects regarding the use of multiple models the discussions in the interviews was broadened and the students were asked about their experiences about contradictions or conflicting descriptions of a phenomenon in their science textbooks in general, and the students were asked to exemplify. Six students claimed that they had never experienced such contradictions or conflicting descriptions.

> S 2 - No, I can not think of any books in which I come across such contradictions.

S4 said he often encountered such contradictions but he could not give an example. S8 claimed that her physics teacher had attracted her attention to contradictions within the phenomenon of acceleration, but she meant that biology was a more precise science in which there were no such contradictions. The only insightful example about a scientific stated contradiction was given by S7 about thermodynamics.

> S7 - It may well be… yes in physics with the conservation of energy and then later, it may be stated [in the textbook] that energy is created. It seems to me, it is so obvious erroneous, so you get disturbed about it.

After showing two contradictory examples in the texts the students were asked how they would react if they encountered two contradictory descriptions (models) of a phenomenon in a textbook, and how they would answer if studying before a test. One student (S5) could not answer and three students (S1, S2 and S8) said they would try to ask the teacher and let him decide what the correct answer is. Otherwise you have to ‘go after your ‘gut feeling’ and use the description you think is right’. These four students more or less regarded conceptual contradictions as flaws in the books.

> S2 - first if you discovered it [in the textbook] you would of course be a little confused by what was true and ask the teacher if he has time, but if it's the night before [a test] you maybe just pick one [way of answering].

S6 answered he would explain as detailed as possible in a test and S3 would show similarities and dissimilarities of the descriptions. Only two students had a more complex way to approach the problem. S7 claimed he would try to describe how the different contradictory aspects related to each other, and S4 interestingly said that he would try to find out in which context the questions are given and answer in a way that is most proper for that context.

> S4 - Yes, then you… if it has been described in different ways, you must try to see in what context the question is given to you in the test.

The use of multiple models in the texts

To be able to understand the use of multiple models it is important to understand science as a way of knowing, i.e. the nature of science (Lederman, 2007). Therefore some of the questions in the interviews revolved about these issues. The students were asked if there is an ultimate 'true' definition of what a gene really is, and whether this definition was presented in the textbook. Six (S1, S3-S6, and S9) of the interviewees believed there was an 'ultimate scientific definition' and three believed no such definition was available. Though the difference between how these two categories of students understood this problem was minor since most of them refer to different descriptions of the phenomenon as either different aspects, i.e. different scientific explanations are thought to capture different spatiotemporal views rather than different theoretical viewpoints, or as different levels of explaining.

> S8 - After all, it is both. The genes are part of the chromosome and they [the genes] also have a DNA, so in that way it is both.

This was also evident when the students in the interviews were shown the different multiple models of gene function visualized in concept maps:

> S4 - It is due to the first explanation is based on the second, in my opinion. The first one over there [points to a concept map of the classical model]; it may represent more of this first text [text 1], perhaps the second one, then goes more into depth.

Only two students understood this question as a part of the development of science as a human endeavour and had therefore the ability to problematize what is meat by a truth in science.

> S7 - Mm. It is perhaps by definition, any other… it may well, if there are different ways to define it [the gene] and maybe you do not agree on what the definition is.

Noteworthy in the interviews, almost no reference was made by the students of how scientific knowledge is acquired in science, i.e. aspects about the nature of science were missing in the students' reflections. All of the interviewed students believed that the genetic content in the textbooks is a mirror the outcomes of science. Hence most students did consider the textbook definition of the gene as a simplistic, less complex version of the scientific.

CONCLUSIONS

From the interviews three main conclusions can be drawn:

- Students have difficulties in detecting the use of multiple models and the conceptual change that occur in a content specific context such as gene function.

- Students do not recognize the existence of conceptual incoherence between different models. If detected it is often regarded as flaws of the textbook.
- The students look upon the different models as different levels of generalization of the phenomenon.

Since the results from the study show that students have severe difficulties in detecting the use of multiple models and the conceptual change that occurs, textbooks ought to provide students with explicit descriptions of models. It is important for students to be aware of: that multiple models can be used to represent a phenomenon; the models fundamental differences; the models contextual use; and possible limitations. To be able to understand this it is crucial to know that the models are human constructs representing different scientific frameworks. An understanding of models and modeling among students is emphasized by many steering documents (The Swedish National Agency for Education, 2009; AAAS 1993), but as have been shown difficult to put into practice if current textbooks are used as the foundation of teaching genetics (Gericke and Hagberg, 2009). This might be a problem since textbooks are established as one the most influential aspects in the planning and execution of biology lessons (Moody, 2000).

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TEACHING MULTIDISCIPLINARY SOFT SKILLS AT ENGINEERING SCHOOL

Franc Gider

Slovenian Technology Agency and University of Nova Gorica

franc.gider@tia.si

Damijan Miklavčič

University of Ljubljana, Faculty of Electrical Engineering

damijan.miklavcic@fe.uni-lj.si

Tomaž Kern

University of Maribor, Faculty of Organizational Sciences

tomaz.kern@fov.uni-mb.si

Borut Likar

University of Primorska, Faculty of Management Koper

borut.likar1@guest.arnes.si

ABSTRACT

In the paper introduction of an interdisciplinary practically oriented course at the Faculty of Electrical Engineering at University of Ljubljana is described. The introduction of the course named Project work and communication in research and development (R&D) has filled the gap in soft skills knowledge of young engineers. The course was taught for three times and was well accepted by the students. Even if it was an elective course at post-graduate study, it was chosen on average by 37,48% of all inscribed students. The trend of the percentage of participating students was rising. The survey among participating students showed that they were satisfied with the content of the course and the teaching approach.

Keywords: *Project management, communication, innovation, problem solving, team work, soft skills, engineering school*.

INTRODUCTION

In today's world, technology is developing very rapidly and most of businesses are getting more and more interdisciplinary (e.g. ICT – the sector where telecommunications and information technologies meet, telemedicine – the emerging sector where medical sciences meet ICT,…). The reason for that can be found in so called "open innovation approach" where new innovative products, technologies and services emerge as a mix of different technologies. On the other hand, one can realize that the research and development projects are no longer isolated processes. They are fully integrated into the corporations in the modern business environment. Projects are mostly even incorporated into more then one company. They are connected to each other and to other business processes in the business system. This is why they need special preparation, management, precise project organization, adapted information support, correct documentation, a special organizational culture, etc.

In most countries the educational system is lagging behind the changes in the business world and universities are still too specialized and "technically oriented". European Commission is getting more and more aware of the facts stated above. Therefore several proposals for improvements of European universities were published (Europa Press Release, 2006).

To prepare the students for work in real business life it is not enough bring them just the new knowledge in form of “cooking recipes” Therefore, it is important to teach students how to acquire newly developed and disseminated knowledge on their own with the help of knowledge technologies (Urbančič, 2007). In the business world, teamwork and networking is becoming more and more important since it brings together different individuals with specific knowledge and personal characteristics. Therefore engineering schools should move more to the direction of teaching “how to tackle a problem” rather than teaching specialized knowledge. Modern university programs usually include many “non-engineering” courses like network intelligence (Palmer, 1998) or creativity and collaboration (Burns and Jordan, 2006).

Young graduates from engineering schools are seemed to be lacking “soft skills” the most (i.e. social and managerial skills, as well as skills related to innovation). Many studies found out that innovation and other soft skills are very important in today’s world and universities should hand these on to students (Likar, 2009, Gider and Urbančič, 2010). To fill that gap, a new interdisciplinary course “Project work and communication in R&D” has been developed at the Faculty of Electrical Engineering at the University of Ljubljana. The main idea of the course was to give the students possibility to gain hands-on experience in conducting research projects by combining knowledge from different backgrounds: conducting research through the study of scientific literature, writing and presenting the results of their work, project management, creativity problem solving in teams and innovation. To make the course as practical as possible, the course was taught by experienced interdisciplinary team of specialists in the fields of project management, written and spoken communication, innovation, and problem solving in teams.

METHODOLOGY

Organisation of the course

The course “Project work and communication in research and development (R&D)” was launched in the academic year 2004/05 as an elective course within the master study program at the Faculty of Electrical Engineering of the University of Ljubljana. The course was on program every second year, all together carried out for 3 times. It has been chosen on average by more than one third of all inscribed students (see the table 1).

In one execution of the course all together 40 contact hours were given to the students. Besides that, the students worked on their own assignments for approximately 20 hours. The contact sessions were carried out in blocks of 4 hours each to optimise the time needed for the completion of the course (all the students were full time employed). The blocks were scheduled on Friday afternoons and Saturday mornings.

The course was divided into four individual modules, which discussed four different, but interrelated topics. The details of the modules are explained below.

A. Innovation management. The module included innovation goals, innovation culture, techniques for innovation boosting, intellectual property rights (IPR), patents, models, integrated circuit topology, registration procedures for IPR, use of web-based tools.

B. Communication in R&D. The module included R&D results presentation, time allotted and audience, collecting and selecting data and information, deciding on the main message, selecting evidences, preparation of visual aids and handouts, planning the presentation and rehearsal, critical evaluation of the performance, answering to questions, writing the abstract, the purpose and structure of the abstract, critical evaluation, communicating through poster, structure and design of a poster, scientific writing, publication structure and basic rules, illustration in scientific papers.

C. Project management. The module included project goals, project phases, basic and specific project goals, duration, project timeline, project resources, project database, planning and scheduling, project monitoring, prediction, decision making and assessment of R&D projects, use of dedicated software packages.

D. Problem solving in teams. The module included team work, roles of team members, tools and techniques for team work, problem definition, root cause analysis, definition of potential solutions, decision making on solutions, solution implementation, business case presentation.

Teaching methods

The faculty for the course consisted of 4 teachers. They came from 4 different universities and had extensive experience in business world in their respective fields (3 of them also successfully run their own firms). During the course, different teaching techniques were used: lectures (approx. 30% of total workload), case studies (10%), practical work in teams (30%) and individual (10%), questions and answers sessions (10%), and homework (10%).

The main features of teaching methods were as described below.

1. Traditional ex-cathedra lectures were combined with modern pedagogical approaches (practical exercises, case study, the study of examples, discussions, ‘hands-on’ experiments, role-plays, simulations…).
2. The lecturers are also practitioners, therefore they could simple switch between theoretical knowledge and practical experience which was very good accepted by the students.
3. From knowledge towards competence: the study concept was focused on both – education process and competencies acquiring (e.g. team work, project work, problem defining and solving, critical analysis, creative thinking etc.).
4. the e-learning tool was an integrated part of the course.

Student exercises

During the course the students worked on four individual and/or team tasks, as follows: (1) students filled a questionnaire on innovation culture in their organisations; (2) students performed current innovation culture status analysis and prepared improvement activity plan; (3) students prepared a project plan for the improvements of innovation culture; and (4) students prepared an abstract of scientific paper.

Two most important focuses of the course were on innovation management and project management. The student exercises related to those focuses are described in the following sections.

Exercise 1: Improvement of innovation and business performance

One of important pedagogical approaches within the subject was a case study representing an interesting model for university-industry cooperation. The aim was to prepare a strategy for business improvement of the organization. The concept was based on modern theory, research results, concrete analysis within the company, strategy prepared by the students and the professors' coaching. It is worth mentioning that the participating professors are experts and researchers on the case study topic publishing in world best journals and professional advisers as well with experiences in best international consulting organizations. The methodology was done in the following steps:

Step 1: Students were asked to perform an Innovation performance research within their company and prepare a short evaluation report. The reports were conducted by using the methodology, which was developed by the teachers. The main areas of evaluation were as follows: Vision and strategic aspects of encouraging innovation; Defining goals and measuring results; Organizational culture and climate; Innovation expenditure; The role of managers; Training and developing employees' competencies; Organizing the idea management processes; Identification of opportunities and generation of inventions; System of material and immaterial rewards; Co-operation for innovation / managing open innovation; The role of communication and sophisticated IT; Factors which inhibit innovation; Measurable results of innovation. Based on the results and theoretical/practical aspect presented within the lectures, the students identified an area(s) where additional efforts could lead to business performance improvement. These areas represented a starting point for the following activities.

Step 2: Collection of data – in order to be able to solve the problem students had to collect relevant data for further analysis.

Step 3: Definition of problem - search for root-causes of the problem.

Step 4: Idea collection – brainstorming for possible solutions.

Step 5: Evaluation of ideas and selection of ideas to be implemented.

Step 6: Planning – preparation of action plan.

Step 7: Presentation of chosen ideas to decision-makers in the firm.

Step 8: Action – implementation of ideas and follow-up.

Exercise 2: Conception and planning of R&D project

We know that R&D projects have to be integrated in the (business or any other) system. Actually projects are only specific way of organizing specific processes. Their main characteristic, in comparison with the other business processes running in the company or institution, is that projects are non-repetitive processes. Due to this, they require special preparation (conception and planning) each time.

We put special attention to the preparation process of the project in our lectures and workshops. Students had to prepare the concepts of development or research projects. They had to define the project purpose, project objectives, and constraints of the project. In the project charter, each student had to develop the content of the project and create the Work Breakdown Structure.

The concepts have been carefully reviewed by the mentor.

The second phase of the workshop was held in small teams. The students independently, based on their concepts, develop project plans. MS Project software tool was used for planning. They define the project phases and project activities, identify the duration of each activity, create network plan, and calculate the duration of the project and project calendar. They identify available resources and assigned them to activities. They optimize resource load (or found overload). Finally they calculate the cost of the project and the cost dynamics.

The project plans have been discussed in teams and reviewed by the mentor.

Evaluation of student satisfaction with the course

The satisfaction of students with the course has been evaluated after each execution of the course. The students answered the questions in the questionnaire, which is presented in the table 1. The questionnaire was divided into three parts: first part consisted of eight questions about the organization of the course, second part consisted of five questions about the content of the course, and third part consisted of questions for each module about the quality of teacher.

Table 1: Questionnaire for the evaluation of student satisfaction

Part 1: Organization of the course - Each question to be evaluated with grades from 1 (poor) to 5 (excellent)
1. The actual content of the course corresponds to the announcement content. 2. Information related to the execution of the course was adequate in content and timing. 3. The time of the course was adequate (days, dates, hours). 4. I regularly participated on the contact hours. 5. My expectations are fully met. 6. I would choose the course again, or recommend it to my colleagues. 7. All modules (A, B, C, D) were represented in the right proportions. 8. The course „Project work and communication in R&D" is the best.
Part 2: Content – open questions
9. State the content which could be omitted: 10. State the content which you missed: 11. State your positive experience with the course / professors: 12. State your negative experience with the course / professors: 13. My other comments:
Part 3: Evaluation of individual modules - Each question to be evaluated with grades from 1 (poor) to 5 (excellent)
A. Innovation management (B. Likar) A1. The teacher was well-prepared for the lectures. A2. The teacher is an expert in the field. A3. The teacher was accessible during the course. A4. The content of the module should be expanded in relation to the other modules. B. Communication in R&D (D. Miklavčič) B1. The teacher was well-prepared for the lectures. B2. The teacher is an expert in the field. B3. The teacher was accessible during the course. B4. The content of the module should be expanded in relation to the other modules. C. Project management (T. Kern) C1. The teacher was well-prepared for the lectures. C2. The teacher is an expert in the field. C3. The teacher was accessible during the course. C4. The content of the module should be expanded in relation to the other modules. D. Problem solving in teams (F. Gider) D1. The teacher was well-prepared for the lectures. D2. The teacher is an expert in the field. D3. The teacher was accessible during the course. D4. The content of the module should be expanded in relation to the other modules.

After the students filled the questionnaire, the results were analysed by using MS Excell spreadsheet software. For each question, mean grades have been calculated.

RESULTS

Number of students chosen the course

First measurement parameter of course performance was the rate of inscribed students, which have chose the course. Increasing percentage of inscribed students taking this course illustrates the interest of students in the skills, which were taught in the course (see the table 2).

Table 2: Number of inscribed students taking the course

Year	No of inscribed students	No of students in the course	Percentage
2001/02	64	17	26,56
2002/03	73	25	34,25
2003/04	81	22	27,16
2004/05	65	16	24,62
2005/06	71	23	32,39
2006/07	77	45	58,44
2007/08	74	34	45,95
2008/09	82	38	46,34
Total	587	220	37,48

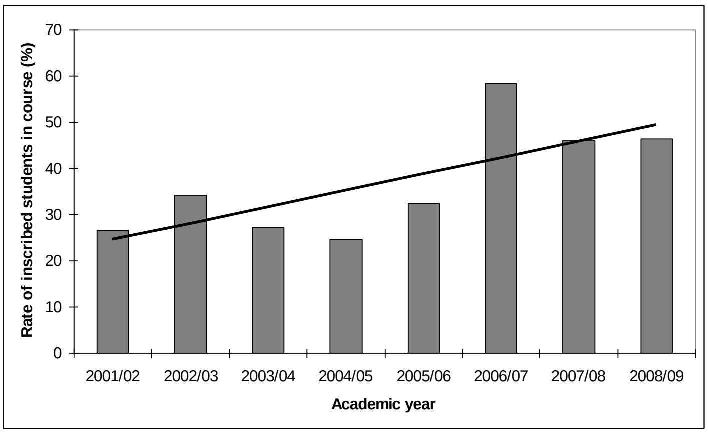

Figure 1: Percentage of inscribed students in course has increased

Attendance ratio

Second parameter of course performance was the presence of students in sessions. For students it was not obligatory to attend the sessions. The analysis showed that the presence on sessions was 66,67% of all students, who have chose the course. Given the fact that the sessions were held on Friday evenings and Saturday mornings, we can state that the interest of the students was relatively high.

Questionnaire results

Third parameter of course performance was the feedback of students after the course. The results of each part of the survey are presented below.

Organization of the course

In the first part of the survey the best grades were assigned to the question nr. 1, and the worst grades to question nr. 3 (see table 3). The results of the first part of the survey suggest that the course in general met the expectations of the students. During the execution of the course the time of sessions was the most inconvenient factor.

Table 3: Results of first part of student survey

Nr.	Question	Grade
1	The actual content of the course corresponds to the announcement content.	4,79
2	Information related to the execution of the course was adequate in content and timing.	4,55
3	The time of the course was adequate (days, dates, hours).	3,79
4	I regularly participated on the contact hours.	4,45
5	My expectations are fully met.	4,33
6	I would choose the course again, or recommend it to my colleagues.	4,73
7	All modules (A, B, C, D) were represented in the right proportions.	3,97
8	The course „Project work and communication in R&D" is the best.	4,06

Content of the course

On the second part of the survey, the answers could be summarized as follows:

Question 9: State the content which could be omitted – approx. 10% of answers suggested that innovation management and team work should be less focussed on.

Question 10: State the content which you missed – less than 10% of the students answered the question. Two most important ideas: writing business plans and more practical work with MS Project software tool.

Question 11: State your positive experience with the course / professors - the students liked the interactive approach with more teachers; cases and exercises during the sessions rather the boring “ex-catedra” teaching; relaxed atmosphere, humour during the sessions; real-life cases used as illustration of the content; cooperation between professors of four different universities.

Question 12: State your negative experience with the course / professors - timing of sessions (Friday evening, Saturday morning); too long sessions (4 hours); some topics could be expanded to more hours (project management); the course was too short to cover all the details of the topics chosen.

Question 13: My other comments – the answers suggested that the students had very positive experience with the course, some of the students suggest that also other engineering schools should consider such course, even in the graduate level.

Evaluation of individual modules of the course

The results of the third part of the survey are presented in the table 4. The results show that the students see the teachers as experts in their respective fields and think that the teachers were well prepared for the course.

Table 4: Results of third part of student survey

Nr.	Question	Grade
A1	The teacher was well-prepared for the lectures.	4,59
A2	The teacher is an expert in the field.	4,53
A3	The teacher was accessible during the course.	4,06
A4	The content of the module should be expanded in relation to the other modules.	2,78
B1	The teacher was well-prepared for the lectures.	4,94
B2	The teacher is an expert in the field.	4,78
B3	The teacher was accessible during the course.	4,66
B4	The content of the module should be expanded in relation to the other modules.	3,97
C1	The teacher was well-prepared for the lectures.	4,84
C2	The teacher is an expert in the field.	4,78
C3	The teacher was accessible during the course.	4,19
C4	The content of the module should be expanded in relation to the other modules.	4,25
D1	The teacher was well-prepared for the lectures.	4,77
D2	The teacher is an expert in the field.	4,57
D3	The teacher was accessible during the course.	3,93
D4	The content of the module should be expanded in relation to the other modules.	3,47

DISCUSSION OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

The course “Project work and communication in R&D” was well-accepted by the students which can be seen from increasing number of students, which have chosen the course over the period of 8 academic years. Also the attendance ratio of the students at the sessions is very positive, given that the sessions were held on Fridays afternoon and Saturdays morning.

From the analysis of the questionnaire we can conclude that the expectations of the students were met in general. The students liked informal atmosphere (with humour) during the sessions. Usefulness of the knowledge and experience, which was taught at the course, was emphasised by practical exercises and team work of the students. The disadvantages of the course could be summarized as follows: the timing of the sessions was not appropriate, and the ratio of hours spent on individual modules should be modified.

For the next executions of the course we should consider the following experience draw from the analysis described in this paper:

1. The content of the course should be revised. The results of the study suggest that the students would expect more balanced content (i.e. more emphasis on the project management and less on innovation management and team work.
2. The sessions should be carried out during the week. Since all the students are employed full-time during the course, the most appropriate solution seems to be shorter sessions (e.g. 2 hours) during the week in the evenings.
3. Some student answers suggest that the course was too short to cover all important aspects of respective modules. An option could be that out of the course described in this paper two separate courses would be developed. One course could be on communication and project management, the other course on problem solving in teams and innovation management. By doing that, the courses could offer more in-depth focus on respective topics with special emphasis on practical exercises.

In general, one could state that the course “Project work and communication in R&D” has been successfully implemented at the Faculty of Electrical Engineering at the University of Ljubljana. With some minor changes the course could even develop further and gain more on its quality.

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TOWARDS THE DEFINITION OF A TEACHER EDUCATION PROGRAM FOR THE USE OF ICT TOOLS IN SCIENCE TEACHING AND LEARNING

Cecília Guerra

University of Aveiro - CIDTFF

3810-193 Aveiro - Portugal

cguerra@ua.pt

António Moreira

University of Aveiro - CIDTFF

3810-193 Aveiro - Portugal

moreira@ua.pt

Rui Marques Vieira

University of Aveiro - CIDTFF

3810-193 Aveiro - Portugal

rvieira@ua.pt

ABSTRACT

The various modalities of integrating Information and Communication Technologies (ICT) in science teaching and learning, as well as the potential and constraints that have emerged from implementing this in the educational context are some of the concerns addressed by an ongoing study in Education at the University of Aveiro. The aim of this study is to develop, implement and evaluate an in-service primary teacher education program for the integration of ICT in the teaching and learning process in general, and in science teaching and learning in particular. The study follows a qualitative research methodology, from an action-research approach. This paper focuses on the first phase of the study, which dealt with the selection of “strategies” and “technology-rich activities” for implementation in an in-service teacher education program at the University of Aveiro and discusses potential barriers to provide in-service primary teachers with integrated technological and pedagogical experiences. It is our ultimate goal, once the study is concluded, to put forth in-service primary teacher education programs in science education based on optimal guidelines derived from data. A complete description of the research methodology, as well as results achieved in this research phase, is put forward.

Keywords: *Sciences teaching methodologies, ICT, sciences learning, teacher education program*

INTRODUCTION

This study is based on three essential premises for science and technology education worldwide, which emerged from the Perth Declaration on Science and Technology Education in 2007 (Fensham, 2008). The first premise is related with the traditional role of science in school, namely motivating pupils to learn sciences, which could be a way to engage them in further studies for careers directly involved with science and technology issues (Harlen, Macro, Reed & Schilling, 2003; Osborne & Dillon, 2008). The second premise is that all pupils need to be prepared to participate actively as individuals and as responsible citizens in our modern society (Osborne & Dillon, 2008). The third premise derives from the changes that Information and Communication Technologies (ICT) have on teachers’ daily work.

A number of researchers have carried out extensive studies on the benefits of ICT use in teachers’ professional lives. Particularly, teachers’ use of ICT tools can improve practical and experimental teaching and learning of sciences. ICT also offers the possibility of interacting with technological and scientific phenomena through simulations, searching for and locating scientific information in online databases, and communicating and collaborating with peers, teachers and scientific experts (Arnold, Padilla & Tunhikorn, 2009; Juuti, Lavonen, Aksela & Meisalo, 2009; Minchi, Michael & Lynn, 2007; Webb, 2005). In this view, teachers should know "where and when (as well as when not) to use the technology for classroom activities and presentations, for management tasks, and to acquire additional subject matter and pedagogical knowledge in support of the teachers' own professional development" (Khan, 2008, p. 6).

However, some researchers have identified several obstacles that explain why science teachers do not integrate ICT in teaching and learning processes. These obstacles include the lack of hardware and software in schools, insufficient teacher education programs in the use of ICT and their applications in science classrooms, and teachers' technophobic attitudes (Guzey & Roehrig, 2009; Juuti, Lavonen, Aksela & Meisalo, 2009).

Koehler & Mishra (2009) say that many teachers had their degrees at a time when educational technology was at the beginning stage of development. Therefore, these authors stressed that "It is, thus, not surprising that they do not consider themselves sufficiently prepared to use technology in the classroom and often do not appreciate its value or relevance to teaching and learning" (Koehler & Mishra, 2009, p. 62). Consequently, higher education institutions should face the development/improvement of pedagogical competences in ICT of the teachers as a continuous process, where the initiation to the pedagogical uses of ICT should be integrated into teacher education programs, as a dynamic and evolving process of professional development of students and in-service primary teachers.

The background of European higher education institutions has changed considerably in recent years, since the implementation of the Bologna Process, as part of a strategy designed to build a European Higher Education Area (EHEA). As a result, Primary Teacher Education programs (undergraduate and postgraduate degrees) were restructured, throughout Portuguese universities and polytechnic institutions, in order to conceive educational opportunities to help students and in-service teachers to develop various pedagogical competences. In this context, the University of Aveiro (Portugal) created a Master's degree in Science Education (2nd Cycle), specifically designed for in-service primary teachers who want to develop/improve their professional knowledge related to science teaching and learning practices. Teachers' professional knowledge is related to several domains, those of knowledge and teaching practice, as well as other professional roles, both inside and outside the classroom, including tutoring, participating in school activities and projects, interacting with members of the community and working in professional groups (Arnold, Padilla & Tunhikorn, 2009; Juuti, Lavonen, Aksela & Meisalo, 2009).

The reorganization of this postgraduate course adhered to EHEA's underlying principles of curricular flexibility, quality and life-long-learning, with the purpose of developing in-service primary teachers' professional knowledge so as to ensure that their pupils will learn sciences better. These in-service primary teachers are simultaneously primary teachers who work with 4 to 12 year-old pupils. The Portuguese legislation for the general profile of teachers' professional performance, such as bills 240/2001 (August 30) and 241/2001 (August 30), refer pedagogical competences in ICT. Therefore, the Master's degree in Science Education included the development and/or improvement of pedagogical competences in ICT of the in-service primary teachers in curricular areas such as “Sciences Teaching Methodologies” and “ICT in Science Education”. The main educational purpose of these curricular areas is to develop in-service primary teachers’ pedagogical competences in ICT.

This study is based on the assumption that it is crucial to develop, implement and evaluate innovative “strategies” and “technology-rich activities” to enhance primary science teachers’ use of ICT, particularly in postgraduate degrees. In this view, it is fundamental to understand which “strategies” and “technology-rich activities” could be put into practice in the curricular areas related to “Sciences Teaching Methodologies” and “ICT in Science Education” at the University of Aveiro Master’s degree in Science Education (2^{nd} Bologna cycle). In this context, it is important to find answers for the following research questions: “What are the optimal guidelines to be adopted for a in-service primary teacher education program, in order to contribute towards the development of primary teachers’ competences in science teaching with and through ICT?”; “What is the impact of the in-service primary teacher education programme thus developed in the primary teachers’ professional knowledge?”.

LITERATURE REVIEW

Outcomes emerged from the specialized scientific community in Education (eLene, 2008; Khan, 2008; Wang, 2008), as well as the underlying principles of Bologna (González & Wagenaar, 2008), and the Organisation for Economic Co-operation and Development (OECD) recommended the integration of ICT into the curriculum plans of Teacher Education Programs. This was based on the assumption that teachers are catalysing agents of “educational change” in schools and ICT could take an important role in this context.

Many studies have shown that the integration of ICT in science teaching and learning can improve pupils’ understanding of scientific and technological concepts (Barton, 2004; Beauchamp & Parkinson, 2008; Eijck & Roth, 2007; Harlen, Macro, Reed & Schilling, 2003; McFarlane & Sakellariou, 2002; Murphy, 2003). For instance, Barton (2004) says that ICT can help pupils and teachers: to deal with abstract ideas and concepts about science and technology; to visualize dynamic processes and complex interactions; to experiment and investigate about scientific and technological phenomena; to look for the relationships between variables (practical work) and to process mathematical data. ICT can also offer the possibility of searching for and locating scientific information in online databases, or communicating and collaborating with peers, teachers and experts.

Several researchers put forward the idea that primary teachers should be engaged with ICT in their practices, within wide social and cultural contexts, because digital educational resources could support both the investigative (skills and attitudes) and more knowledge-based aspects (concepts) of the pupils (Barton, 2004; Harlen, Macro, Reed & Schilling, 2003; Murphy, 2003). According to van Eijck & Roth (2007), the integration of ICT-based research tools in science teaching could facilitate the promotion of pupils’ active participation in inquiry. ICT-based research tools include hardware (i.e. sensors for data collection) as well as software (i.e. simulations). These authors also consider that the role of ICT-based research tools could contribute towards the development of pupils’ scientific literacy. Additionally, the integration of e-learning platforms, Web 2.0 tools (i.e. blogs, podcasts) and mobile instruments (i.e. phones) in the teaching and learning process might improve students’ learning about several subjects (Redecker, 2008), such as sciences.

In this view, primary teachers should be able to structure problem-tasks and integrate ICT tools with pupil-centred teaching methods, and play an important role in creating and implementing a vision of school as a community based on innovation and continuous learning of sciences, enriched by ICT (Barton, 2004; Harlen, Macro, Reed & Schilling, 2003; Murphy, 2003). Nevertheless, in order to make effective use of ICT "… teachers need to believe not only that affordances of these environments can support their students' learning but also that they themselves have a crucial role in planning and managing the learning experiences…" (Webb, 2005, p. 733). Therefore, it is vital to develop/improve the pedagogical competences in ICT of students and in-service primary teachers (undergraduate and postgraduate degrees, respectively).

The United Nations Educational, Scientific and Cultural Organization (UNESCO) published the "ICT Competency Standards for Teachers (ICT-CST)" framework with guidelines for the development of teacher education programs. The framework refers the competences to be developed by teachers and within each competence it details different teaching and learning methodologies (Khan, 2008). The standards proposed by UNESCO were based on three approaches to education reform: a) *technology literacy* - increasing the technological uptake of the workforce by incorporating technology skills in the curriculum; b) *knowledge deepening approach* - increasing the ability of the workforce to use knowledge to add value to economic output by applying it to solve complex, real-world problems; c) *knowledge creation approach* - increasing the ability of the workforce to innovate and produce new knowledge and of citizens to benefit from this new knowledge (Khan, 2008).

The development of *technology literacy* cited in UNESCO ICT-CST usually takes place under a technical training perspective, which is related to the mastery of the technical instruments and computing tools, from a more instrumental perspective (Khan, 2008). However, several authors stress the idea that these technological competences shouldn't be developed as separate from the pedagogical aspects related to the use of ICT in teaching and learning processes. Consequently, teachers should develop/improve pedagogical competences related to the integration of ICT into the curriculum, which in turn will help them explore technology to help pupils collaborate, access information, communicate with external experts, share, analyze and solve problems, as well as to learn throughout their lives. This underlying approach is harmonized with the UNESCO ICT-CST framework, in which competences related to *the knowledge deepening approach* should include the competences of teachers in promoting, for instance, individual pupil and group project work. Additionally, it should enable collaboration with other teachers and foster the use of networking tools to support their own professional development (Khan, 2008). Finally, in the UNESCO ICT-CST framework, teachers who show competence within the *knowledge creation approach* will be able to design ICT-based learning resources and environments so as to support the development of knowledge creation and critical thinking skills of pupils, and create knowledge communities for pupils and colleagues. This level of training will play an important role in creating and sustaining a vision of the school as a community based on innovation and continuous learning, enriched by ICT (Khan, 2008).

In this context, primary teacher education programmes should be based on the concept of learning outcomes, which are statements that emerge from the Bologna principles, which describe what a student or in-service teacher is expected to know, understand and/or be able to demonstrate at the end of a degree (undergraduate and postgraduate). Therefore, teaching and learning activities should be synchronized with the learning outcomes and should move from a teacher-centred approach (focused on what the teacher does) to one that should be centred on student involvement in the learning process (González & Wagenaar, 2008).

As to the development/improvement of students' competences, members of the Joint Quality Initiative (JQI) proposed a set of descriptors, called the Dublin Descriptors, which have been established for 1st, 2nd and 3rd Bologna cycles. According to these descriptors, after each degree cycle, students are expected to have attained a certain level of competences across five broad learning outcomes: knowledge and understanding, application of knowledge and understanding, making judgments, communication and learning skills (González & Wagenaar, 2008).

The Dublin Descriptors are related to all curricular areas and define attributes such as problem solving, communication, writing, research, and teamwork competences of the students. Therefore, at the end of each cycle, students should have the ability to gather and interpret relevant data related with their field of study in order to inform judgements that include reflection on relevant social, scientific or ethical issues. It is also important that students can communicate information, ideas, problems and solutions to both specialist and non-specialist audiences. Finally, students should develop those learning competences that are necessary for them to continue to undertake further studies with a high degree of autonomy(González & Wagenaar, 2008).

In this higher education context, curriculum areas should include the following aspects: a) types of teaching and learning activities (i.e. lecture, seminar, tutorial, project work, etc.); b) types of learning activities (i.e. attending lectures, practising technical or laboratory skills, chairing meetings, etc.); c) types of student assessment (i.e. oral presentation, paper/essay, portfolio, report on fieldwork, continuous assessment (i.e. final thesis/dissertation, etc.) (González & Wagenaar, 2008). A social constructivist framework for innovation design of curricular areas has been described by Ferdig (2006). According to this author, and based on the research of Salomon (1993), innovations must congregate academic content and practice in order to create authentic and engaging activities for students. Then, innovative design should include five components. First, innovation must contain authentic, meaningful and real-word problems that engage students in learning. Second, students should have the opportunity to take on a self-regulating role in their learning process. Third, a pedagogical innovation should be imbued with opportunities for active participation, collaboration and social interaction of students. Fourth, pedagogical innovations must afford opportunities for the creation of artefacts. Those artefacts should represent students' understanding of the problem, resulting solutions and emergent states of knowledge. Finally, innovations should stress the importance of publication, reflection and feedback.

Moreira & Loureiro (2008) suggest the articulation between Learning/Technology/Interaction in in-service teacher education programs, which could improve the relationships between students and teachers, between them, the learning content and the technological tools, so as to achieve improved students' learning outcomes. In this context, technological and pedagogical content knowledge (TPCK) should be the basis of effective teaching with technology. This should require "an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge to develop new epistemologies or strengthen old ones" (Koehler & Mishra, 2009, p. 66).

Brush & Saye (2009), based on Lee (2008), focus on a set of guidelines for effectively integrating TPCK into a social studies context, such as: locating and adapting digital resources for use in the classroom; facilitating students' work in nonlinear environments; using the Internet to extend collaboration and communication among students; extending and promoting active and authentic forms of human interaction and technology enabled social networks.

A complete description of the research methodology as well as results achieved in this research phase will be put forward in the following sections.

RESEARCH METHODOLOGY

A qualitative research methodology, through an action-research approach, was adopted in this study. The research process was organized in the following steps: to identify the research objectives of the data collection instruments; to review literature, pertinent to the research objectives of the data collection instruments; to organize the corpus of analysis from the several tasks (1st and 2nd tasks); to develop a data analysis instrument; to categorize the data in defined dimensions, sub-dimensions and categories of analysis; and to have the data analysis instrument validated by a panel of experts in teacher education programs, with pedagogical competences in ICT.

Table 1 summarizes the techniques and instruments of data collection and analysis adopted in each research task.

Table 1 - Techniques and instruments of data collection and analysis

Task	Data Collecting			Data Analysis
	Techniques	Instruments	Participants	Techniques
1st Task	Document analysis	Document analysis instrument	Researcher of the study	Content analysis
	Inquiry	Semi-structured interview	4 national ET researchers	Content analysis
2nd Task	Observation	Research diary	Researcher of the study and 2 teacher-trainers	Content analysis

The **1st task** occurred from January 2009 to November 2009, and comprehended two data collection moments. The aims of this task were: to understand which pedagogical and technological competences should be developed in primary science teacher education programs (under and postgraduation degrees); to identify the main programmatic areas in Educational Technologies that could be articulated with sciences teaching and learning; to define which teaching and learning perspectives could be implemented in sciences teaching and learning; and to identify the learning evaluation perspectives which could be adopted to assess students' learning outcomes in this context.

In the first moment, several programs of curricular areas related to Educational Technology (ET) (i.e., "ICT in education") were analysed from an exploratory point of view. Data were obtained from "Basic Education" degrees (1st Bologna cycle), offered by Portuguese public higher education institutions (7 universities and 13 polytechnic institutions). Document analysis was adopted in this task because it was an unobtrusive technique and it was used without imposing face-to-face participation of the teacher-trainees who developed the curriculum programs. In a second moment, four national educational technology researchers were interviewed. The researchers were specialized in the development of primary teacher education programmes (undergraduate and postgraduate degrees) and one of them was an expert in science education research. The semi-structured interview had predefined open questions, but further questions were used by the interviewer during the conversations with the researchers (Bardin, 2000; Bauer, 2000).

In the **2nd task**, a case study was undertaken in the curricular areas of "Sciences Teaching Methodologies" and "ICT in Science Education" of the University of Aveiro Master's degree in Science Education (2nd Bologna cycle). The aim of this task was to describe and understand the development process of the in-service primary teacher education program, with the aim of articulating those two curricular areas in order to contribute towards the development of primary teachers' competences in science teaching with and through ICT.

This task comprehended one data collection moment, which occurred from December 2009 to January 2010, through participant observation performed by the researcher during the collaborative work with the two teacher-trainers of those curricular areas. The teachers-trainers were asked to participate in this project, based on their formative and research interests, as well as the interest of the Master's degree in Science Education (2nd Cycle), which was specifically designed for in-service primary teachers who want to develop/improve their professional knowledge related to science teaching and learning practices. Collaborative work between the researcher and the teacher-trainers occurred in four face-to-face sessions and through online interactions on a social network platform (Ning). This process proved to be an efficient communication medium between all the elements of the team. Each of the curricular areas had its individuality, mainly in terms of *subject area* ("Sciences Teaching Methodologies" and "ICT in Science Education"). Collaborative work focused on the reflective discussions between the researcher and the teacher-trainers, articulating the "guidelines" that emerged throughout the first phase of this study, the literature review about the subject area, and the respective learning outcomes previously envisaged for each of those curricular areas. Research diaries were produced by the researcher along this task, which included two levels of information: descriptive and reflective. The descriptive level addressed facts about date, place, participants and activities developed (all sessions were audio-recorded and transcribed). The reflective level aimed to reflect preliminary outcomes of the study, from the researcher's point of view.

Data were analysed from an exploratory point of view under a content analysis methodology. A descriptive methodology was implemented through a *nomothetic* approach, in order to identify underlying trends and/or patterns in the collected data (Bardin, 2000; Bauer, 2000). The dimensions, sub-dimensions and categories of analysis were established based on the research aims and supported by the literature review, specifically the recommendations made by the EHEA (González & Wagenaar, 2008) and the primary teacher education profile proposed by the Science Education scientific community as to the use of ICT in teaching and learning (Arnold, Padilla & Tunhikorn, 2009; Juuti, Lavonen, Aksela & Meisalo, 2009; Minchi, Michael & Lynn, 2007; Webb, 2005).

RESULTS AND DISCUSSION

In the **1st task**, data analysis showed that it is important to develop/improve *primary teachers' innovative pedagogical competences in ICT*. This result emerged from content analysis of the programs of the curricular areas related to ET, an aspect also suggested by two of the members of the national educational technology researchers interviewed. This level of *pedagogical competences in ICT* could allow in-service primary teachers to develop critical thinking in order to reflect about their own professional practices, incorporate research in their sciences teaching and learning activities and expand pedagogical innovations in the classroom within the educational community (Khan, 2008). Several authors defend that this type of *innovative pedagogical competences in ICT* should be developed through teacher education programs at a postgraduation level (2nd and 3rd Bologna Cycle) (Costa, Rodrigues, Peralta, Cruz, Reis, Ramos, Sebastião, Maio, Dias, Gomes, Osório, Ramos & Valente, 2008).

However, two other experts suggested that it is important to identify training needs of the in-service primary teachers. In fact, one of the obstacles that explain why primary teachers do not integrate ICT in teaching and learning processes have to do with the lack of (i) teacher education programs in the use of ICT and (ii) the reduced application of technologies in science classrooms, as well as teachers' technophobic attitudes (Guzey & Roehrig, 2009).

Content analysis also allowed identifying the *main programmatic areas in ET that could be articulated with sciences teaching and learning*. These were: locating and adapting ICT tolls for use in the sciences classroom; facilitating in-service primary teachers' work in nonlinear environments; using the Internet (i.e. social networks) to extend collaboration and communication among in-service primary teachers and their teacher-trainees (or other colleagues).

Data analysis showed that it is important to promote inquiry-based learning activities in science classrooms *with* and *through* ICT-based research tools. This *teaching and learning approach* could be a promising way to promote in-service primary teachers' pedagogical competences in ICT and could contribute for the development of their pupils' scientific literacy (Eijck & Roth, 2007). Finally, data analysis showed that *continuous and formative assessment* should be adopted to assess in-service primary teachers' learning outcomes. This could be achieved trough the development of several instruments by the in-service primary teachers themselves, such as presentations, scientific papers, digital portfolios and reports on fieldwork (González & Wagenaar, 2008).

Data obtained from the **2nd task** helped apply an innovative design of the curricular areas of "Sciences Teaching Methodologies" and "ICT in Science Education" (Ferdig, 2006). The in-service primary teacher education program was offered in a blended-Learning regime, comprising two face-to-face sessions per week – one in "Sciences Teaching Methodologies" and another in "ICT in Science Education". In between those face-to-face sessions, distance work took place throughout the week.

The team discussed and selected the following innovative strategies to be implemented concurrently to each curricular area (Ferdig, 2006): to provide authentic, meaningful and real-word problems to the in-service primary teachers and thus engaging them to sciences and technological learning with and through ICT; to give the opportunity to the in-service primary teachers to take on a self-regulating role in their learning process; to afford opportunities for active participation, collaboration and social interaction of the in-service primary teachers; to afford opportunities for the creation of artefacts, which should represent in-service primary teachers' understanding of the problem, resulting solutions and emergent states of knowledge; to embrace the importance of publication, reflection and feedback.

These strategies involved the integration of several technology-rich activities into various aspects of the curricular areas. The aim was to promote in-service primary teachers' deep understanding of the multiple technology tools (hardware and software) available (in their educational contexts and on the Internet), and to show them how those tools can be used to enhance a wide variety of activities in sciences teaching and learning.

One technology-rich activity was related to the exploitation of real case studies, conducted by primary teachers and researchers that promoted the integration of ICT-based research tools in science teaching and learning. These case studies were provided through the organization of several seminars organized in the curricular area of "Sciences Teaching Methodologies". Additionally, in-service primary teachers accessed scientific literature available online. The educational goal of this technology-rich activity was to allow in-service primary teachers to access and discuss the potentialities and constrains of ICT integration in science teaching and learning, and its role in facilitating the promotion of pupils' active participation in inquiry in sciences classrooms.

Another technology-rich activity aimed to provide in-service primary teachers with opportunities to implement small research projects that effectively utilize ICT-based research tools in their sciences classroom contexts. The ICT-based research tools should be available at their schools and/or accessible via the Internet. The educational goals of this activity were: to motivate in-service primary teachers to collaboratively design a technology-based activity for their pupils, implement and evaluate the effectiveness of that activity in pupils' understanding of scientific and technological concepts; to support in-service primary teachers' professional development enabling them to develop their practice, and connect with others in the field.

These technology-rich activities afforded learning opportunities to in-service primary teachers to explore several technological tools: Ning, with the aim of enhancing social networking between in-service primary teachers and their teacher-trainees; *box.net* with the aim of sharing available videos, audio/podcasts and scientific literature about research studies that endorse the integration of ICT-based research tools in science teaching and learning, etc.; MinMeister with the aim of enhancing collaborative mind-mapping in order to understand the representation of scientific and technological concepts using technologies; WordPress, a blogging tool with the aim of developing digital portfolios in order to give the in-service primary teachers the opportunity to take on a self-regulating role in their learning process. In-service primary teachers were asked to integrate their critical reflections, activity resources, and other artefacts in their digital portfolios. Additionally, in-service primary teachers should reflect upon how well the technology supported the goals of the activity and what modifications they would make to future iterations of the activity in their digital portfolios;

Pbwork, a wiki tool with the aim of collaboratively (in dyads) developing a scientific paper about the literature review and research methodology adopted in their research projects; mobile phones with the aim of improving in-service primary teachers' questioning skills about several subjects (they were asked to send reflective questions to the teacher-trainees, after each seminar); sensors with the aim of promoting practical and experimental activities in "Sciences Teaching Methodologies" and in "ICT in Science Education".

The seminars, the small research projects developed by the in-service primary teachers, as well as the experimental activities that were developed, are presently being audio and video recorded and shared in the social network (Ning) so as to provide in-service primary teachers with opportunities to explore the interaction of technology, pedagogy, and content, thus providing, we hope, optimal sciences learning environments.

In-service primary teachers' learning outcomes follow *continuous and formative assessment* approaches. This will be based on the scrutiny of products developed by the in-service primary teachers: a scientific paper (Pbwork); a digital portfolio (Blog); a concept-map (MinMeister); and the interactions in the Ning forums. Those products should represent in-service primary teachers' understanding of the problem, the resulting solutions and emergent states and increments of knowledge. According to Ferdig (2006), innovations should embrace the importance of publication, reflection and feedback. These products will allow teacher-trainees to infer the process by which in-service primary teachers transform meanings and strategies shared and co-constructed in the social network, making those strategies their own.

A symposium is being prepared, to take place at the end of the training programme, so that the in-service primary teachers have the opportunity to make public the results of their projects, but also and especially to allow them to share and discuss the strategies implemented and validated/assessed next to the national community of sciences teachers and researchers.

CONCLUSIONS

This study is based on the assumption that it is crucial to develop, implement and evaluate innovative strategies and technology-rich activities to enhance primary science teachers' use of ICT, particularly at postgraduation level.

This paper addresses which optimal guidelines were put into practice in the curricular areas related to "Sciences Teaching Methodologies" and "ICT in Science Education" at the University of Aveiro Master's degree in Science Education (2nd Bologna cycle). The development of synergies between the curricular areas of "Sciences Teaching Methodologies" and "ICT in Science Education" were underline at: the research level, where in-service primary teachers were asked to conduct research studies about real problems related to the teaching and learning process of sciences; at the professional level, where it was important to relate all subjects with professional practices of the in-service primary teachers; and at the curricular level, related to the formative dimension of teaching methodologies in postgraduate teacher training courses (i.e. education for sustainable development).

Finally, the central subject of each curricular areas aimed at developing *innovative pedagogical competences in ICT* related to in-service primary teachers' professional lives, namely (i) integrating ICT into sciences teaching practices; ii) promoting and exploring interaction practices when planning pedagogical activities (for formal and/or non-formal contexts); iii) developing collaborative work; and iv) developing research competences (Costa, Rodrigues, Peralta, Cruz, Reis, Ramos, Sebastião, Maio, Dias, Gomes, Osório, Ramos & Valente, 2008).

An in-service teacher education program was developed in order to improve the relationships between in-service primary teachers and teachers-trainees, between the learning content and between the technological tools, so as to achieve improved in-service primary teachers' learning outcomes (Moreira & Loureiro, 2008).

The strategies and technology-rich activities were designed to increase in-service primary teachers' TPCK by providing them with opportunities to explore innovative and emerging ICT-based research tools in authentic science teaching and learning contexts. As Koehler & Mishra (2009) stated, TPCK should be the basis of effective teaching with technology, which requires an understanding of the representation of concepts using technologies as well as pedagogical competences to integrate those technologies in constructive ways to teach content, such as sciences.

However, it is still necessary to evaluate the extent to which this knowledge transfers to actual classroom practices once these in-service primary teachers obtain their grades in those curricular areas. Consequently, it is imperative to find answers for the following research question: What is the impact of the in-service teacher education programme thus developed in the primary teachers' professional knowledge?

Therefore, the purpose of the second and third research phases of the study is to evaluate the effectiveness and mid-term impact of the in-service primary teacher education programme. Specifically, it is important to assess if the strategies and technology-rich activities adopted will develop/improve several pedagogical competences in ICT of those in-service primary teachers, such as: critical thinking in order to reflect about their own professional practices; incorporate research outcomes in their sciences teaching and learning activities; expand pedagogical innovations in the classroom within the educational community. The results of this later stage of the study will be the object of future writings.

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DETERMINING ELEMENTARY SCHOOL SCIENCE EDUCATION PRE-SERVICE TEACHERS' CRITICAL THINKING SKILLS THROUGH THE STORY OF THE RAPA NUI- EASTER ISLAND

Hayriye Gül Kuruyer

Aksaray University

Faculty of Education

kuruyergul@yahoo.com

Dr. Sibel Özsoy

Aksaray University

Faculty of Education

sozsoy@aksaray.edu.tr

Dilek Altun

Middle East Technical University

Faculty of Education

daltun@metu.edu.tr

ABSTRACT

The purpose of this study is to determine elementary school science pre- service teachers' critical thinking skills through the story of the Rapa Nui- Easter Island. The study was conducted in the fall semester of 2009-2010 academic year. Participants of the study consisted of 29 pre-service teachers; 21 females and 8 males, enrolling to elementary school science education department of one of the universities in Türkiye. To determine critical thinking levels, six open- ended questions were prepared by researchers based on six dimensions of critical thinking skills reported in Delphi project. Pre-service teachers were asked to read the story of Easter Island and answer six open-ended questions. Results of the study revealed that most of the pre-service teachers were efficient in categorization, examining ideas, drawing conclusions, stating results and self-examination. Besides, results also showed that most of the participants were not efficient in decoding significance, assessing arguments, justifying procedures, presenting arguments and self-correction.

Keywords: *Environmental education, critical thinking skills, pre-service teachers.*

INTRODUCTION

Rapid population growth and over consumption of resources produce increasing pressures on the Earth causing over-exploitation of non-renewable resources, and production of more waste that can be absorbed and processed by the nature (Environmental Protection Agency, 2003). This situation results in increasing pollution, poor air and water quality, and the extinction of numerous animal and plant species.

Today, environmental problems are experienced on a global scale and impact more and more of the human population. The deterioration of the global environment has become a leading concern for all communities and interest in environmental problems has increased both in international and national level. To determine the current situation of the planet Earth and find ways to solve environmental problems many meetings were conducted with the participation of attendees from different countries. In 1972, in one of these meetings, United Nations Conference on the Human Environment and Development (UNCHED), the term 'sustainable development' was established (Reed, 1996; Williams, 1993) with a hope of leaving future generations a world that is worth to live in it. The term came into common usage with the publication of the Brundtland Commission Report (World Commission on

Environment and Development [WCED], 1987). In this report the term is defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland Commission, 1987). Sustainable development calls a redefinition of the relationship between man and the environment. It aims to find a balance between providing human needs with protecting the environment (Goldman, Yavetz & Pe'er, 2006). With this respect, sustainable living can be achieved by continuous evaluation of human needs in terms of their potential impacts on future generations (Brown, Flavin & Postel, as cited in Orr, 1992). The concept of sustainable development is multidimensional; it focuses on relationships between three areas; environment, society and economy, for the well being of human populations (Brundtland Commission, 1987). According to Goodland (1995), it incorporates the ability of each area to maintain itself without impacting the other areas in negative way. With this respect the goal of sustainable development is to provide secure economic development, social equity and justice, conserve natural resources and support environmental protection (Humphries, 2004). Sustainable development enforces us to think about the welfare of all species both today and tomorrow (Humphries, 2004).

Through the discussion and formulation of the concept of sustainable development, it became apparent that education is needed to accomplish it. Fien (2002) argues that education for sustainable development is a key component in addressing the challenge of sustainability. In the UNCHED report 'education for sustainable development' is defined as an "emerging but dynamic concept that encompasses a new version of education that seeks to empower people of all ages to assume responsibility for creating a sustainable future" (p.7). To achieve the aim of creating a sustainable future, there must be a paradigm shift in human behavior with respect to the environment. In order to make the shift we have to educate citizens who can realize environmental problems and produce solutions to solve them.

Critical thinking is essential in understanding, analyzing and interpreting environmental problems. There has been much debate among researches on the definition of 'critical thinking' (Kennedy, Fisher & Ennis, 1991). For this reason, there is no single and universally agreed definition of critical thinking. One of the most widely accepted definition of critical thinking is stated by Robert Ennis. According to Ennis (1987), "critical thinking is reasonable, reflective thinking that is aimed that at deciding what to believe or what to do" (n.p.). Besides, Chaffe (1988) stated that "critical thinking is making sense of our world by carefully examining our thinking, and the thinking of others, in order to clarify and improve our understanding" (p.5). In 1990s, American Philosophical Association assembled experts to reach a consensus on a definition and dimensions of critical thinking. This assembly, The Delphi Project, provided considerable insight and direction about critical thinking and characteristics of critical thinkers. In the Delphi Project (1990) it is stated that;

> *We understand critical thinking to be purposeful, self regulatory judgement which results in interpretation, analysis, evaluation and inference as well as explanation of the evidential conceptual, methodological, criteriological or contextual considerations upon which that judgement was based. Critical thinking is essential as a tool of inquiry. Critical thinking is a pervasive and self-rectifying human phenomenon. The ideal critical thinker is habitually inquisitive, well-informed, honest in facing personal biases, prudent in making judgements, willing to consider, clear about issues, orderly in complex matters, diligent in seeking relevant information, reasonable in selection of criteria, focused in inquiry, and persistent in seeking results which are precise as the subject and the circumstances of inquiry permit (p.4)*

While there are still disagreements about critical thinking, giving a precise definition is not in the scope of this paper. For the purpose of this study dimensions of critical thinking; interpretation, analysis, evaluation, inference and explanation and self-regulation, determined in Delphi Project (1990) are considered.

To improve children's critical thinking, schools must review what they are doing and what they are achieving. It is proved that critical thinking skills are not learned well unless teachers emphasize use of critical thinking skills during the teaching process (Howe & Disinger, 1990). To educate students as critical thinkers, teachers should have efficient critical thinking skills. With this perspective investigating pre-service and in-service teachers' critical thinking skills becomes very important. For this reason the purpose of this study is to determine pre-service teachers' critical thinking skills through an environmental story; Rapa-Nui.

PROCEDURE

Participants of the Study

The study was carried out in the fall semester of 2009-2010 academic year. Data of the study were obtained from 29 freshmen students; 21 girls and 8 boys, enrolling to the elementary school science education program of one of the universities in Türkiye.

Instrument

According to Howe and Disinger, "providing experiences in real life situations or situations that simulate real life situations increase the probability that critical thinking skills will be used" (p.4). Story of the Rapa-Nui Island provides a real life situation for pre-service teachers in which they can clarify the problems, deduce data needed to solve the problem, evaluate sources of information critically and develop solution strategies. Six open-ended questions were prepared by researchers based on the story of the Rapa-Nui Island. To determine the critical thinking skills, in a 30 minute period, pre-service teachers were asked to read the story about the Easter Island and answer the open-ended questions below.

1. Explain and list the environmental problems experienced Rapa-Nui Island.

2. Analyze the situation in Rapa-Nui by considering your beliefs, judgments and experiences.

3. Evaluate the events happened in Rapa-Nui.

4. How the problems experienced in Rapa-Nui can be solved? By considering the problems in the Rapa- Nui describe current environmental problems and their consequences.

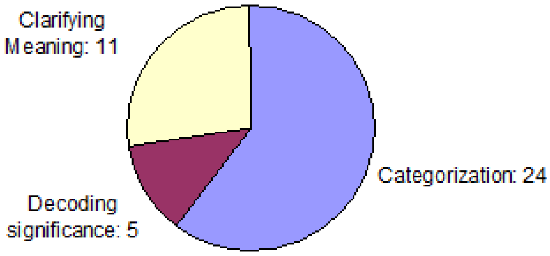
5. Summarize the situation in Rapa-Nui with your own wording.

6. Review the story and your responses then evaluate your performance.

Analysis of the Data

The participants' responses to the questions comprise the data set used for the analysis. The data obtained were analyzed by using content analysis procedures. Before coding, the researchers overviewed all the responses for each question to determine meaningful data units. Then, a list of codes was created by noting all the features included in the questionnaires. In the next step, these codes were put under the subcategories of critical thinking defined beforehand.

RESULTS



Interpretation:

When pre-service teachers' responses belonging to the skill of interpretation are examined, it is found that there are 24 expressions that can be covered by categorization sub-skill.

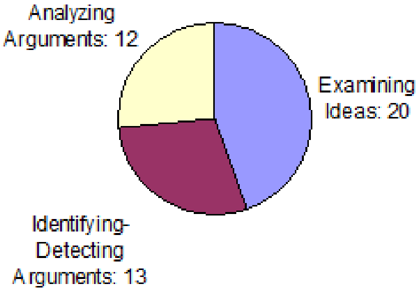
Example replies of pre-service teachers for the categorization sub-skill are as follows:

- Cutting of trees, loss of green areas, inability to process the land are some of the environmental problems experienced in Rapa-Nui.
- Limited amount of natural resources, resource depletion and conflicts experienced because of these problems
- Inadequacy in food, increase in population, resource depletion

Besides, results also showed that pre-service teachers were not efficient on decoding significance. Only 5 responses can be devoted to this sub-skill. Several examples of responses are:

- People who settled the island use natural resources unconsciously. They act without thinking the consequences of their behaviors.
- There is a limited space, so to grow plants people continuously cut down the trees on the island. Besides they don't plant the new ones instead. The result is increasing environmental problems.

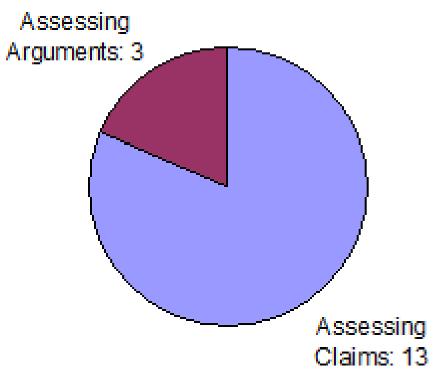
Analysis:



Analysis skill includes three sub-skills; examining ideas, identifying and detecting arguments and analyzing arguments. For the examining sub-skill pre-service teachers were found to be efficient. The results showed that 20 pre-service teachers gave responses that can be attributed to examining ideas sub-skill, 13 of them gave responses appropriate to identifying and detecting arguments and 12 pre-service teachers gave responses that can be categorized in analyzing arguments sub-skill. Several responses for examining ideas sub-skill are given below:

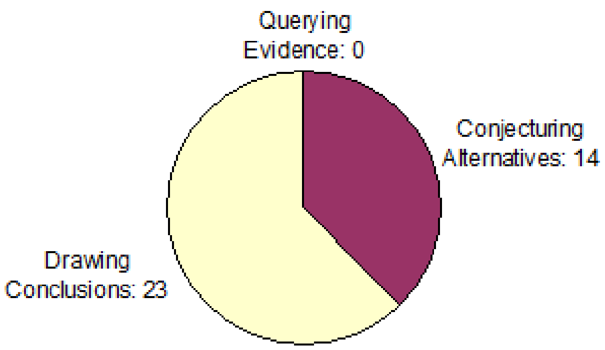
- In Rapa-Nui, people exhausted resources without considering their future. Unconsciously, they did harm to themselves and to their environment. Increasing population and consumption caused a disaster.
- People inhabited the island to escape from war, epidemic diseases etc. Population on the island increases throughout the time. With increasing population and depletion of resources people die of starvation. At last, the civilization on the island ends.

Evaluation:



Assessing the arguments and claims are the two sub-skills belonging to the evaluation skill. Results of the study showed that pre-service teachers do not effectively assess arguments. There are only three representative responses for assessing arguments sub-skill. In one example of response a pre-service teacher stated that “To live in the island, people built houses, they plant potatoes. However, their inconsiderate actions caused the civilization to end.”

Inference:

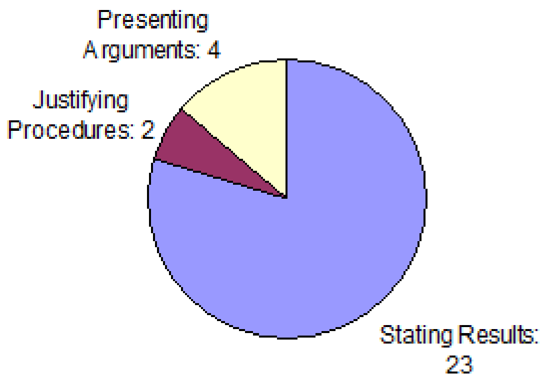


Inference skill consists of subscales of querying evidence, conjecturing alternatives and drawing conclusions. Among these three sub-skills, pre-service teachers were found to be not effective in querying evidence. Besides, they are fairly good in drawing conclusions.

Example replies of pre-service teachers for the drawing conclusion sub-skill are as follows:

- Today, we experience similar environmental problems. The reason for global warming is because of the inconsiderate actions of human beings. The life on the earth will end as occurred in the island.
- Today, similar in the island, we cut down trees and do not plant the new ones. For this reason the structure of the soil changes, and the ecological balance is completely changed.

Explanation:

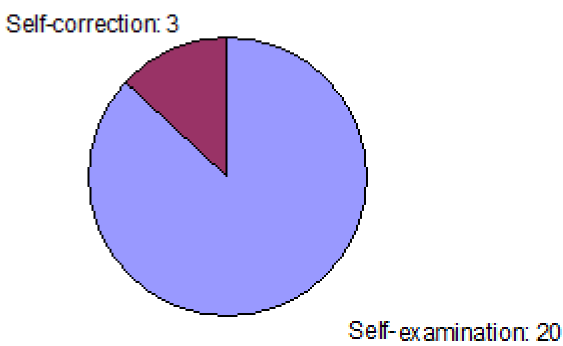


Justifying procedures, presenting arguments and stating results are the three sub-skills grouped under the explanation skill. Although pre-service teachers were found to be effective in stating results, they are not in presenting arguments and in justifying procedures.

Sample representative responses are;

- If we do not act in a planned and systematic way, we will experience the same end *(Justifying procedures)*
- We have to stop environmental degradation, consume resources in a planned way and solve the current environmental problems. *(Presenting arguments)*
- People degraded the food and natural resources in the island. Increase in population caused a competition to get the required sources.*(Stating results)*

Self-regulation:



Self-regulation is the last skill included in critical thinking. Self-correction and self-examination are the two sub-skills grouped under the self-regulation. Results of the study showed that although teachers are effective in self-examination, they are not in self correction.

CONCLUSION

Environmental education is an area in which critical thinking has always been a prior goal (Kyburz- Graber, Wolfensberger & Hofer, 2003). In schools, we expect teachers to teach students critical thinking skills. In order for teachers to be able to implement critical thinking into their classrooms, teachers should be effective critical thinkers. With this respect, it is important to determine pre-service and in-service teachers' critical thinking skills.

The purpose of this study was to determine elementary school science pre-service teachers' critical thinking skills through the story of the Easter Island. Results of the study revealed that most of the pre-service teachers were efficient in categorization, examining ideas, drawing conclusions, stating results and self-examination. Besides, results also showed that most of the participants were not efficient in decoding significance, assessing arguments, justifying procedures, presenting arguments and self-correction.

According to results, it can be concluded that participants are not fully efficient critical thinkers. Based on these results, it can be said that these pre-service teachers will not be effective in applying critical thinking skills in their lessons and cannot teach critical thinking to their students. Considering the results, we have to think over the current teacher education curricula and make urgent revisions on it to improve pre-service teachers' critical thinking skills.

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SCIENCE EDUCATION: BASED ON EVIDENCE OR ON A COMMITMENT TO 'BILDUNG'?

Henrik Hallström

Department of Teacher Education,

Halmstad University, Sweden

henrik.hallstrom@hh.se

Magnus Levinsson

Department of Educational Science, University of Gothenburg, Sweden

magnus.levinsson@ped.gu.se

ABSTRACT

Decreasing student performance and difficulties in recruiting students to careers in science have raised questions concerning the quality of science education in Sweden. The government has recognized the seriousness of the situation and has invested significantly in research and development work in order to reverse this trend. The policies pursued points towards an evidence-based reform in science education that seems to conflict with the current educational system. By investigating a set of projects accomplished by the *Evidence-based Practice in Science Education* (EPSE) *Network* in England this paper examines factors of science teaching that require attention in a move towards evidence-based practice. The lessons learned from the EPSE Network are put in relation to the distinction between two ideal perspectives of teaching – the 'Didactical perspective' and the 'Curriculum perspective'. The results indicate that a move towards evidence-based practice requires a 'Curriculum perspective' of teaching and that an evidence-based reform threatens to reduce autonomy, replace professional judgment and prevent deliberations about the overall purpose of science education in Sweden.

Keywords: *Bildung, Didaktik, Evidence-Based Practice, Science Education, Science Teaching*

TOWARDS EVIDENCE-BASED PRACTICE IN SWEDEN

There is a widespread problem within science education regarding decreasing student performance and difficulties in recruiting students to study science. This issue has raised questions about the quality of science education and major discussions on how to reverse this trend (e.g. Osborne et al., 2008). The move towards 'evidence-based practice' (EBP) is considered as a promising way forward for science education in this matter (e.g. Millar, et al., 2006), and governments have been recommended to support an evidence-based reform (OECD, 2003; 2007). Currently in Sweden, this seems to be the case. TIMSS and PISA have indicated that Sweden's position has dropped in the ranking as a result of decreasing achievements over the past 20 years (National Agency of Education, 2009). As a result, the Swedish government has invested significantly in research and development work in science education. 125 million SEK has been assigned to the National Agency for Education to improve the quality of science teaching in schools across the country (Department of Education, 2009a). The Swedish Minister for Education clarifies how this investment is planned to raise standards of achievement (SR, 2009):

> Most teaching is good, even very good, and then it is a question of how to disseminate the good strategies that can be found at some schools to other schools. The National Agency of Education and the Center for Mathematical Sciences in Gothenburg will be responsible for this task. Further, schools that have good strategies will get opportunities to participate in various projects to develop and disseminate them to other schools. (Authors´ translation)

The Swedish government encourages the improvement of science classroom-work in a rather straightforward manner. As such, there are similarities between the government's idea of how 'good teaching strategies' are supposed to result in students´ performances and the leading principle of the evidence-based movement – that is, using strategies of 'what works' (e.g. Slavin, 2002).

In Sweden there has been a growing discontentment with the present line of educational research for not providing a relevant body of knowledge on which teachers and policy-makers can draw (e.g. SOU, 2008:30). Hence, a more explicit push for EBP has been promoted. The Swedish government has proposed to raise the requirements of practical relevance to make clear that the aim of the funded educational research is to '…contribute to a more evidence-based school and preschool' (Department of Education, 2009b, p. 58). A recent official report (SOU, 2009:94) suggests collaboration with the established Danish Clearinghouse founded to conduct systematic reviews of interventions and to provide stakeholders with a source of scientific evidence of 'what works' in education. The Swedish report points out that it may function as a mean to raise '…standards and promote evidence-based practices' in Sweden (Department of Education, 2008, p. 8). To sum up, the Swedish government pursues a line of policy that brings about transformations of both science education practice and research, and that makes it reasonable to expect a move towards EBP (Biesta, 2007; Slavin, 2002).

It should be noted that EBP in education have been developed in different directions that makes different assumptions about the role of research in practice (technical, cultural and critical), the degree of involvement of teachers in research, the nature of teacher professional knowledge and what should count as evidence (ranging from RCT, claimed to be the 'gold standard' in some cases, to include educational research in general). These differences are also reflected in the various terms used to conceptualize different aspects of the EBP movement e.g. 'evidence-informed', 'practice-based evidence', and 'outcome-based education' (Thomas & Pring, 2004). However, as mentioned above, the Swedish government seems to promote a direction of EBP that operates in the 'what works' frame, also known as the 'classical model' of EBP, in which educational research, ideally, should provide teachers with effective and applicable strategies (Hammerslay, 2004; Traianou, 2009). This model assumes that research can and should play a technical role in practice, first of all, to improve the outcomes of teaching (e.g. Elliot, 2001). Henceforth, it is to this 'classical model' that this paper refers in the case of EBP in science education.

This paper examines what to require of science teaching in a move towards EBP in Sweden by investigating a set of projects previously accomplished by the *Evidence-based Practice in Science Education* (EPSE) *Network* in England. The work of EPSE and their use of the term EBP has previously been compared to the 'classical model' (Traianou & Hammersley, 2008) which makes the lessons learned from EPSE a relevant point of departure for an investigation of what might be required of science education in an evidence-based reform in Sweden. This paper argues that the centralized agenda-setting of 'what works' seems to conflict with the current educational system in Sweden since the present curriculum offers teachers a great deal of autonomy to realize the national curricula in the context of their own school and classroom. To illustrate in what way EBP threatens to replace professional judgment of teachers, and prevents wider deliberations of the ends of education, this paper examines the lessons learned from the EPSE Network in relation to the distinction between the 'Didactical' and the 'Curriculum' perspective of teaching (Hopmann, 2007). Potential consequences of an evidence-based reform in science education in Sweden will be discussed.

LESSONS LEARNED FROM THE EPSE NETWORK

The aim of the EPSE Network (part of the *Teaching and Learning Research Programme*) was to explore factors influencing the move of school science towards a more evidence-based practice (Millar et al., 2006). To achieve this, the EPSE Network pursued four interrelated projects and in sum they conclude that…

> …research has a clearer and more valuable role in the design of a teaching intervention, or in generating evidence of the effects of an intervention, if that intervention is relatively short, and has clear learning objectives whose attainment can be measured (ibid., p. 177).

That which the EPSE Network call 'grain size' – the size of the 'units' of teaching and learning in question – is recognized to be of decisive importance for the contribution that research can make in the development of school science. The 'grain size' is considered in a scale ranging from more broader teaching approaches, applicable across subjects, to more specific teaching strategies, focusing on specific learning objectives within a subject domain. The lessons learned from the EPSE projects points out that research in science education can make effective contributions to issues and questions on a more fine grade scale and that researchers, teachers and policy-makers have to think of science teaching and learning 'in terms of smaller, more tightly focused 'units' (ibid, s. 159). If the units are smaller and more focused it might be reasonable to suggest that it is easier to identify clear learning outcomes and appropriate ways of measuring them. The EPSE Network underlines that the pre-specification of curriculum goals in terms of measurable learning outcomes is a prerequisite for determining the efficiency of different science teaching activities. Otherwise it would be quite difficult for research to provide clear and useful evidence of to which extent a particular teaching strategy achieves its intended learning outcome. One of the EPSE Network projects clarifies how valid and reliable measurements can be developed. In an attempt to assess understanding, the team developed a 'measuring-tool' based on '…an operational definition of 'understanding' as the ability to answer a particular question (or set of questions) correctly or to carry out a particular task (or set of tasks) appropriately…' (ibid., p. 165). The results from this project indicate that researchers can provide teachers with useful tools to measure students' understanding, collect evidence of students' learning and clarify learning outcomes in specific subject domains.

Another reason for approaching school science on a finer grade scale is that it brings research on student's understanding of the natural world to the fore. The EPSE network states that '…the importance and value of this research as a resource of improving practice is considerable' (ibid., p. 163). With respect to school science, it might be possible to direct efforts towards specific topics and basic ideas that are recognized as the most conceptually demanding or to pose the greatest difficulties for students. The research on student's understanding is also important in the development of new teaching strategies because it may indicate missing steps and the order in which topics and ideas are introduced. EPSE argues that a well-defined teaching strategy might also facilitate the dissemination as they carry fewer learning objectives, a smaller number of theoretical ideas and have less disturbance on everyday routines.

The lessons learned from the EPSE Network provide insights into what to require of science education in a forthcoming move towards EBP. But it also provides an important opportunity to more closely consider the consequences for the current school system in Sweden.

DIFFERENT PERSPECTIVES OF SCIENCE TEACHING

The move towards a more evidence-based school science requires a perspective of teaching that has close points of similarities with what Hopmann (2007) refers to as the 'Curriculum perspective' (the two different perspectives on teaching presented in this section should be seen as ideal types of teaching to clarify implications of EBP for teachers and teaching). The 'Curriculum perspective' of teaching is, from Hopmann's point of view, about transporting knowledge to students, or put differently, about 'teaching what to learn' (**Figure 1**.).

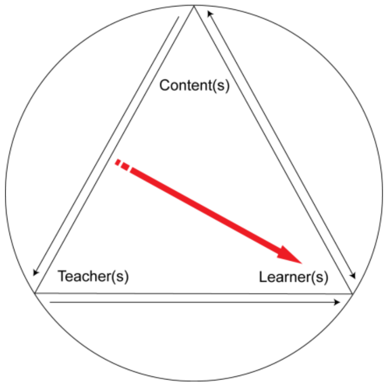

Figure 1. Teaching what to learn

The efforts made by the EPSE Network to improve subject matter teaching and learning requires that schooling is about 'transporting' school science knowledge to students. For instance ... the EPSE network exemplifies how research can contribute to teaching and learning on a more 'fine grade' scale by drawing an analogy with evidence-based medicine. The educational equivalent '…is 'treating' a *specific* knowledge or skills deficit – a lack of understanding of a specific topic or idea, or an inability to carry out a specific procedure…' (ibid., p, 159). The key assumption made by the EPSE Network is that research most likely will render that 'transporting' of knowledge more effective – so that the teaching of X leads, in a rather straightforward manner, to the learning of X – otherwise the hard work of the Network team would be a waste of efforts. This assumption applies even better if school science is considered on a finer grade scale, as exemplified by the EPSE Network analogy with evidence-based medicine. The educational equivalent directs teaching towards specific topics and basic ideas, recognized by the scientific community to be of importance for the development of understanding in each subject. In other words, EBP requires, not only, that teachers should teach what students should learn, but also, that teachers should teach on a specific level and in a specific order – justified by the EPSE Network's view of school science knowledge as…

… hierarchical, with more powerful ideas building upon more fundamental ones, implying an order in which learning can best take place. Science education can, perhaps to a greater extent than some other curriculum subjects, reasonably be seen as a largely goal-directed activity (ibid., p.161).

The ‘Curriculum perspective’ of teaching is a necessity to make room for the ‘key elements’ (specified curriculum goals and appropriate measurements) of EBP. ‘What to learn’ has to be given in order to define it more closely and to set it in measurable terms. The EPSE network’s definition of understanding, as the ability to answer particular questions correctly or to carry out particular tasks appropriately, describes how students’ should master the content in a specific subject domain. It exemplifies how ‘what to learn’ can be more closely framed. A well-defined assignment is a requisite to get hold of the quality of teaching in the ways suggested by the EPSE Network. Teachers can collect evidence of their performance by assessing the distance between student’s achievements and ‘what to learn’ (**Figure 2.**).

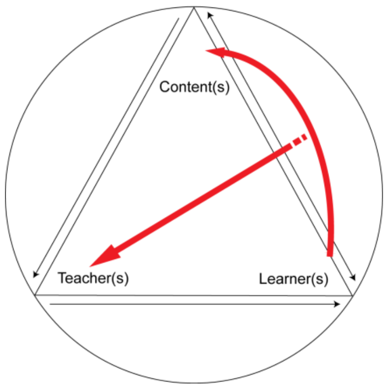

Figure 2. Assessment of distance

An evidence-based school science (drawing on the ‘classical model’ of EBP) requires a ‘Curriculum perspective’ of teaching. This perspective is quite different to the ‘Didactical perspective’, influential in the preparatory work (SOU, 1992:94) of the most recent school reform in Sweden. Differences that is far from surprising, since the perspectives have been developed within different traditions (Westbury et al., 2000). However, these differences leaves us with an interesting comparison that highlights how an evidence-based reform threatens to reduce autonomy, replace professional judgment, and prevent wider deliberations of the overall purpose of science education

According to Hopmann (2007) the common core of the ‘Didactical perspective’ is based on a) a commitment to ‘Bildung’ b) the educative difference of matter and meaning, and c) the autonomy of teaching and learning. A central idea in the concept of ‘Bildung’ is that whatever is learned in the classroom is learned to develop and open up the individuality and the sociability of the student. Science teaching is, from this point of view, not about transporting knowledge from teacher to student, rather it is a about ‘learning by teaching’, where school science knowledge is used as a transformative tool for unfolding the capabilities of the student.

Bildung reminds us that the meeting itself and its outcome are not embedded in the content or given by the teaching, but only emerge on site, then and there where the meeting between a particular student and a particular content happen (ibid, p. 115).

To realize this – 'Bildung' – teaching has to deal with the content in a way which is aware of the educative difference of matter and meaning (**Figure. 3**). The subject matter listed in the curriculum is, of course, without its educative meaning. It arises first in the very act of teaching, in the meeting of teacher, student and content in the classroom (ibid.).

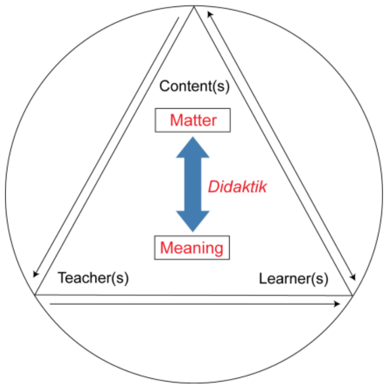

Figure 3. The educative difference of matter and meaning

In the 'Didactical perspective' any given matter can represent several different meanings, and any given meaning can arise from several different matters. This notion is important because it clarifies that the quality of teaching doesn't necessarily depend on student's mastery of the content, nor is the quality possible to be captured by assessing the distance between achievements and intended outcomes. The quality of teaching is more dependent on if and how the educative meaning is opened up for the student, '…if and how it became open in their individual meeting with the content in the given teaching process' (Hopmann, 2007, p. 117).

This difference, of matter and meaning, is absent in the perspective of science teaching required of an evidence-based reform (implemented according to the 'classical model'). If there were a notion of meaning, then meaning would have to be synonymous with the matter, or put differently, one given matter opens up one given meaning, and vice versa. However, in the 'Didactical perspective' of teaching no one can ever, in advance, assure that a meeting of teacher, student and content ends up in reaching the intended meaning.

> What comes out in terms of Bildung is indeed often not visible at all, at least not right away. It depends on what remains after the hurly burly of teaching is done, the battle of minds is lost or won, and the student comes to terms with his or her own world (Hopmann, 2007, p. 11)

This condition – that 'Bildung' never can be taken for granted – is essential in the 'Didactical perspective' and it calls for a great deal of autonomy for both students and teachers. The autonomy is necessary for teachers struggling to unfold certain educative meanings in the meeting of certain students and certain contents. But once in the classroom, one learns that it can always turn out completely differently. If the patterns were given – that is, it is possible to find out 'what works' – the autonomy would be denied and the capabilities of teachers would be reduced to and dependent on their ability to apply certain evidence-based strategies hitting certain pre-specified targets.

CLOSING REFLECTIONS

The move towards EBP in science education has attracted much attention as a promising way to reverse the trend of decreasing student achievement in science education. The corresponding investment of the Swedish government might be seen as a sound initiative to raise standards in science education. However, the lessons learned from the EPSE Network projects highlights that the development of EBP is a major undertaking. It will require a lot of efforts from stakeholders if educational research is to play an important part in the development of evidence-based science teaching and learning in Sweden. Researchers, teachers and policymakers have to adopt a more 'fine grade' view of school science. But also, as illustrated in this paper, the move towards the 'classical model' of EBP demands a 'Curriculum perspective' of teaching that conflicts with the 'Didactical perspective' and the current curriculum in Sweden. This deserves attention because an evidence-based reform will probably involve a fundamental change of the conditions for teachers and teaching, and threatens to reduce autonomy, replace professional judgment, and the wider deliberations of the ends of science education in Sweden. It is important that researchers, teachers and policy-makers in Sweden take this notion into consideration before deciding if an evidence-based reform is worthwhile.

If the potential threats are taken seriously science education in Sweden has to pay more attention to the common core of the 'Didactical perspective' (a commitment to 'Bildung', the educative difference of matter and meaning and the autonomy of teaching and learning) in the development of EBP. The burning question in this paper is whether science teaching and learning should be based on evidence or on a commitment to Bildung? This question is valid when the 'classical model' of EBP is considered, often explicit in the expectations that policymakers hold about what evidence can and should do in relation to educational practice (Biesta, 2007). Other directions within the evidence-based movement that makes different assumptions (e.g. about the role of research in practice, the involvement of teachers in research, the nature of professional knowledge and what should count as evidence) might not require a 'Curriculum perspective' or stand in contrast to the 'Didactical perspective' of teaching. Rather, they might offer a way forward to reclaim the notion of EBP and develop a direction within science education that includes the 'Didactical perspective' of teaching and encourages ongoing deliberations about the overall purpose of schooling. But this is beyond the scoop of the present paper and will be saved for future investigation.

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LEARNING SCIENCE WITH ADVANCED LEARNING BLOCKS

Boris Horvat

Institute of mathematics, physics and mechanics and Faculty of mathematics and physics, University of Ljubljana

boris.horvat@fmf.uni-lj.si

Primož Lukšič

Institute of mathematics, physics and mechanics and Faculty of mathematics and physics, University of Ljubljana

primoz.luksic@fmf.uni-lj.si

ABSTRACT

Recent studies have shown that teachers need e-learning content that they can easily adapt and reuse for their own purposes. This means that lessons should be made out of small learning blocks or, as they are called, “knowledge objects” / “learning blocks”. A new concept of how to create really useful e-learning content was evolved in Slovenia; namely, by “putting the teacher back into the game”. The selection of proper technologies and tools for managing e-learning content and the establishment of a user-friendly and easy-to-use environment for creating and modifying e-learning content, are essential to ensure basic support and popularization of e-learning.

In this paper, we will present new ideas with proofs of concepts of “modular, really interactive e-content” build on the top of the mathematical, physical, logical and computer-scientific knowledge using open-source solutions, open standards and some programming. E-learning content which will be discussed is not intended to be an electronic teaching book, but the add-on to the standard learning material. You can see some of the results at http://www.nauk.si.

Keywords: *e-learning content, educational content preparation, knowledge extraction, ICT in learning, ICT in science*

INTRODUCTION

In recent years, the process of a creation of electronic educational learning content (e-learning content) in Slovenia has been carried out for the most part with disregard to the teacher; by utilization of a two-way relationship between the authors and the users of the content - the learners (Horvat et al., 2010).

Using experience obtained while leading and cooperating on several EU and Slovenian research projects involving e-learning and e-content creation (Horvat et al., 2007A, 2007B, Lukšič et al., 2007, Božeglav et al., 2009, Horvat et al., 2009), a new concept of how to create really useful e-learning content evolved in Slovenia; namely, by "putting the teacher back into the game".

The manual for teaching employees of the Institute for Interactive Media and Learning University of Technology Sydney (Teaching Matters, 2009) states that one of the important characteristics of a good teacher is if he or she uses the learning materials in a manner best suited to the course, which he or she is currently teaching. Also, a research done in South Korea (Hwang, 2008) on teachers' satisfaction with available e-learning content, gave interesting results. It showed that one of the main factors that affects satisfaction with the e-learning content (and hence its actual use in the classroom) is the possibility that this content can be adapted to the teacher's method of teaching.

By being involved in two projects "Learning Programming" (Lukšič et al., 2009) and "Active Mathematics" (Lokar et al., 2009), which were co-funded by the Ministry of Education and Sports of the Republic of Slovenia, the authors of this paper cooperated in transfering knowledge and experience of preparation and use of e-learning teaching materials (Batagelj et al., 2007 and 2009), acquired over the years, to practice. Specifically, the most important experience was again, that teachers need and want e-learning content that they can easily adapt and reuse for their own purposes.

As the teacher usually serves as an intermediate between teaching materials and the learner, he or she should be able to make all proper choices concerning which content to use and how to combine it into a lesson. This means that lessons should be made out of small learning blocks or, as we will call them, "knowledge objects" or “learning blocks”. In this way, the teacher will be able to change the lesson and promptly adapt the learning process to the situation in the classroom.

In this paper, proofs of concepts of "modular, really interactive e-content" build on the top of the mathematical, physical, logical and computer-scientific knowledge, using open-source solutions, open standards and some programming, will be presented. E-learning content that will be discussed is not intended to be an electronic teaching book, but the add-on to the standard learning material. Some of the examples can already be seen at http://www.nauk.si.

CONCEPTS AND ADVANCED LEARNING BLOCKS

The authors of this paper are members of the NAUK team (NAUK – Advanced learning blocks group, Lokar et al., 2009), which is a group that manages several projects in progress, involved in e-learning content creation. The common aim of NAUK projects is to create a computer-powered system for managing and serving e-learning content that will be extremely suitable for teachers. The main difference between NAUK projects and other software systems for e-learning content creation is in the philosophy supporting the project; namely, instead of the author-learner relation NAUK projects want to introduce the three-way author-teacher-learner relation.

The main idea behind the NAUK concepts is that the teacher will take the teaching materials from the already available online sources, prepared within different content creation projects/systems and, with the help of NAUK system, change and combine them to make a lesson that suits his or her style of teaching and/or the current situation in the classroom. As he or she will be using the resulting content in different situations, the underlying system will offer different ways of export, that conform to the most important up-to-date standards.

Therefore, NAUK project group conceived a concept that would allow combining existing content and with that the creation of one's own learning pathways. With that the project group wanted to tackle, among others, the following widely recognized problems associated with the existing e-learning content:

- it is often realized as a digitized book, without proper interactivity and is multimedia-poor;
- it is linearly structured, although the process of learning is usually not linear;
- it has no contextual dependencies, which are useful while informing the learner about his / her mistakes and the consequences resulting from these errors;
- insufficiently uses new teaching approaches - students will often use the content when a teacher is not present, therefore the concept of multiple interpretation of the same topic is very important, as well as the motivation, progressive building of knowledge, examinations, etc.;
- learners use the same e-learning content several times - some parts of the content should be modified automatically but in such a way that all presentations require the same process of learning (e.g., counting apples is the same as counting rabbits);
- instructions for the teacher are missing - how to present the material, what is the goal or purpose of the content on each step, etc;
- the content is too strongly integrated into the presentation of the material - no revisions and changes are possible (the structure is too monolith);
- there is no real interactivity - the question is not if but how can the augmented reality and other innovative ways be used to improve the learning process.

While observing available e-learning content, group members also found certain shortcomings in prior approaches, mainly through the reactions of the teachers; see also (Prensky, 2001). Although teachers got the opportunity to combine and adapt the learning content, it was quite a difficult task for them. It required non-basic knowledge of managing of virtual learning environments (VLE) and at the same time substantial knowledge of different ICT standards: HTML, CSS, JavaScript, SCORM, etc.

Furthermore, it was a mistake to expect that teachers will only use the materials. They also had didactic and technical comments, since they will be the ones who will teach with the content. However, the biggest surprise has been that the majority of them did not want to create new content, but just to adapt the existing one. Whether this was due to the lack of motivation, the complexity of the process or the poor quality of the available content, it was necessary to find the problems and to fix them.

One thing that has also been neglected in other content creation tools is the process of knowledge extraction. Teachers do not just want some basic quiz type questions but often want to randomize questions, offer feedback for the frequent errors, use structured questions that challenge the learner and therefore make a nonlinear path through the process of examination and teaching/learning. Because each question is a knowledge object, all this will be possible with the use of the NAUK software. Finally, authors of the content have generally been people trained in ICT. If we want teachers with little or no practice to use the software, the software will have to be very intuitive and user-friendly.

The NAUK team also found out that it is not enough to offer only content; it has to be inserted in the appropriate classification system and properly interlinked. A creation of a large repositories of e-learning materials will start a new process; that is, a process of creation of e-learning books that will become a supplement to well-known physical teaching materials. Although physical teaching materials can be used even decades after they are published (printed), this is not the case with e-learning materials. Since e-learning materials are built using different technologies and standards (Varlamis & Apostolakis, 2006), special care should be taken to develop such a process that adapting the presentation of e-learning books to new technologies and standards, in not so distant future, will be possible.

Group members are involved in several projects in progress that are aimed to make e-learning content for: high-school mathematics, primary- and secondary-school physics, elementary-school logic, all pre-faculty levels of computer science classes and faculty-level mathematics. Creating a repository of e-learning content – see Figure 1 – from six different fields of knowledge (at the same time on different levels), promises a greater range of users but also demands a greater responsibility from the group.

The basic idea of NAUK's approach can be easily compared with the popular Lego[4] blocks; see Figure 2-4. The e-learning material should be built by creating: basic / simple building blocks, predesigned e-learning material, which can be later customized, and instructions for preparing customized e-learning material by using simpler building blocks.

When preparing the content, it is important to take into the account its entire life-cycle, which includes the process of creation, use and alteration of the material. The whole process of managing e-learning content is well described in van Assche & Vuorikari, 2006.

Figure 1: The NAUK group portal (NAUK – Advanced learning blocks)[5].

The lack of tools that are easy to use, but at the same time provide the functionality that is needed for quality education, and technical knowledge that is necessary for the implementation of electronic-based education, are the main obstacles today in Slovenia that make the wider use of e-learning in the school environment as well as outside, impossible.

[4] http://www.lego.com
[5] http://www.nauk.si

Figure 2: Basic building blocks[6]

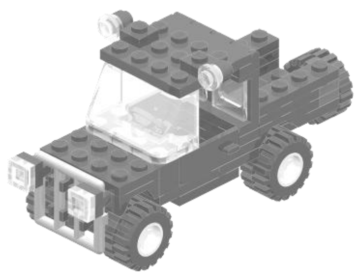

Figure 3: Predesign models (that can be later customized)[7]

Figure 4: Instructions for advanced customized models[8]

TOOLS FOR E-LEARNING CONTENT CREATION

The selection of proper technologies and tools for managing e-learning content and the establishment of a user-friendly and easy-to-use environment for creating and modifying e-learning content, are essential to ensure basic support and the popularization of e-learning. Of course selecting the technologies and the tools is not a task for the teacher. Creating an environment that will offer quality e-learning creation tools and related services is the goal of the interdisciplinary group of experts with skills from: multimedia, web technologies, web services, user interface design, programming, teaching with the usage of ICT, ect. Such a group was formed in one of NAUK's project named e-SIGMA (Services for building interactive content from mathematics), where they intend to offer technological support to educational material creation process in the context of other NAUK projects.

The main component of the proposed collection of services is the repository of materials, which, unlike the majority of existing systems, is not only intended for archiving and serving content, but at the same time offers the possibility of combining existing materials into new learning units. Sustainability and reusability in light of new technologies of thus created e-learning materials is the main advantage to the existing monolithic presentation of e-learning content that can be currently be seen all over the web. The main scenarios that were envisaged before creating the repository are:

- A teacher constructs a learning path, i.e. a complete learning course for teaching specific topics in the curriculum.
- A teacher that uses a virtual learning environment creates an assessment and imports it into the virtual learning environment.
- A teacher prepares homework with the same content as the teaching material he or she used while teaching, but with different data for every learner.
- A teacher modifies and reuses an already prepared assessment.
- A teacher modifies and reuses an already prepared content.
- A teacher adds interactive elements or descriptions on transitions between elements to already prepared content.
- A teacher uses mathematical notation.

[6] source: http://www.turbosquid.com
[7] source: http://www.track7.org
[8] source: http://www.lego.com

- A teacher comments and grades an already prepared content.
- A teacher contributes his or her own content into the repository.
- A teacher creates new teaching materials or assessments.

Since the process of creation and modification of interactive elements should be as simple as possible, the project group decided to use a similar markup syntax used by the well-known wiki environments, e.g. by Wikipedia[9]. Of course, NAUK's syntax contains additional tags, thereby enabling the addition of various multimedia elements and links between e-learning materials, adding responses to user input, etc. Example of the syntax is shown in Figure 5. In the continuation of the project, the project group intends to offer a graphical editor (powered by AJAX technology[10] - Asynchronous JavaScript and XML) to replace the writing of tags and further simplify the process of e-learning content creation.

By using NAUK services that are currently still in beta version and are intended to become stable in October 2010, the teacher will be able to take existing content from the repository, amend or supplement it, and immediately publish it in the repository. The other important functionality of the repository would be the possibility of exporting the content in the SCORM[11] standard. The teacher will be able to use the e-learning content exported in SCORM in his/her own virtual learning environment (e.g. Moodle, BlackBoard, Dokeos, etc.). Thus, by using NAUK's export service the requirement for technical knowledge of the author (teacher) becomes obsolete.

Therefore, the teacher is no longer obliged to blindly follow the ideas of the original authors of the content, but is able to accommodate the content to his or her needs. He or she can easily:

- take a few questions from existing quizzes (or question banks that store Moodle[12] questions, STACK[13] questions) and build a new quiz,
- add or improve responses (feedbacks) depending on the correctness of the answer to a question or an interactive part of the teaching material,
- take an already built teaching material, remove or replace a certain section, change the order of chapters and slides, etc.,
- correct an animation or add his or her own example,
- build a context aware test from a database of questions, where the the next question displayed depends on the correctness of the answer to the previous question,
- add leaps in a learning pathway and thereby build a non-linear structure.

[9] http://www.wikipedia.org
[10] http://www.w3schools.com/Ajax/
[11] http://www.adlnet.gov/Technologies/scorm/
[12] http://www.moodle.org
[13] http://sourceforge.net/projects/stack/

Figure 5: Example for the wiki-like syntax that is used in NAUK projects to describe e-learning content.

The foundation of NAUK system for e-learning content creation uses GIT[14] distributed version control system that greatly enhances the functionality of service by providing the possibility of:

- comparing differences between versions of the stored e-learning material,
- easing the possibility of modifying the already existing content by starting a new branch, and becoming an author (owner) of a new branch,
- cooperating with other coauthors in writing the same content.

Often overlooked feature needed by repositories of educational content are efficient search engines. Most of current repositories in Slovenia contain "search by the title", some of them also include "search by the content", but almost all of them lack the option to search by other metadata taxonomies: type of materials, their purpose, scope, popularity, level of difficulty, etc. This is precisely the problem of current Slovenian educational network - SIO (Čač et al., 2007), which is being filled with an increasing amount of material but has problems when searching for specific content due to the lack of correct classification. We are therefore forced to review a great deal of content on the same subject to see that some consists only of a single PDF document, others are learning paths, the third kind links to other places on the Internet, etc. This is the reason why eache-learning content in the NAUK repository must be equipped with metadata, which enables the system to classify the materials with regard to different taxonomies: curriculum, content, etc.

Different authors are already making materials in the e-Sigma repository in the context of the projects NAUK. Although the project group is adding new functionalities, the form of the content is largely fixed, which means that teachers do not have to take care of the appearance (representation) of their teaching material, but only of the content, interactivity,

[14] http://git-scm.com/

multimedia add-ons and their place within the learning path of the e-learning material. Example of an exercise can be seen in Figure 5 and its an automatically generated presentation in Figure 6. The presentation is generated automatically when the teacher enters the type of items that he or she wishes to have, e.g. some text, matching question type, hint button with text for the hint and the jump button.

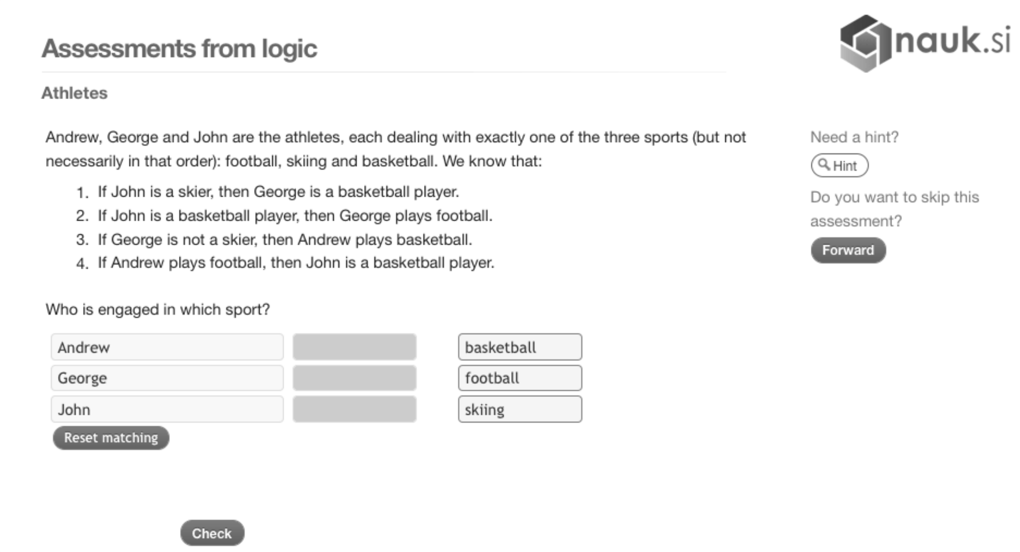

Figure 6: An assessment from logic built automatically by the NAUK system from scenario shown in Figure 5. The learner is supposed to move the correct answers to locations to match sports with players.

Authors can build the content by using the following building blocks: title, subtitle, ..., text, stylized text, table, ordered list, unordered list, link, internal link, button, hint, download, image, video, sound, flash, java applet (Geogebra), gallery, sequence of images, data plot, mathematical notation, virtual book, star map, hotspots, single-choice question, multi-choice question, matching, random-choice exercise, tabbed view, meta data, custom assessments from logic, additional information for teachers, slide menu, etc. The content can be grouped in one, two or three columns that make a slide, slides form sections (with subsections, subsubsections, etc.), sections can be grouped into advanced learning blocks and advanced learning blocks form an e-learning content. The author can choose from different types of slides, e.g. normal slide, popup slide, dragable slide, etc.

Authors can overlay the so-called "tools" above the multimedia content: video, image, plot of the data - measurements, etc. The currently available tools are: angle, distance, vector, vertical lines, horizontal lines, freehand drawing, stop watch, polyline; see Figure 7. By using the tools the author can demand from a learner to "naturally" interact while learning, by solving puzzles, answering quizzes, measuring distances and angles between objects on images or videos, responding to questions by drawing an image or a vector, by constructing a graph, etc.

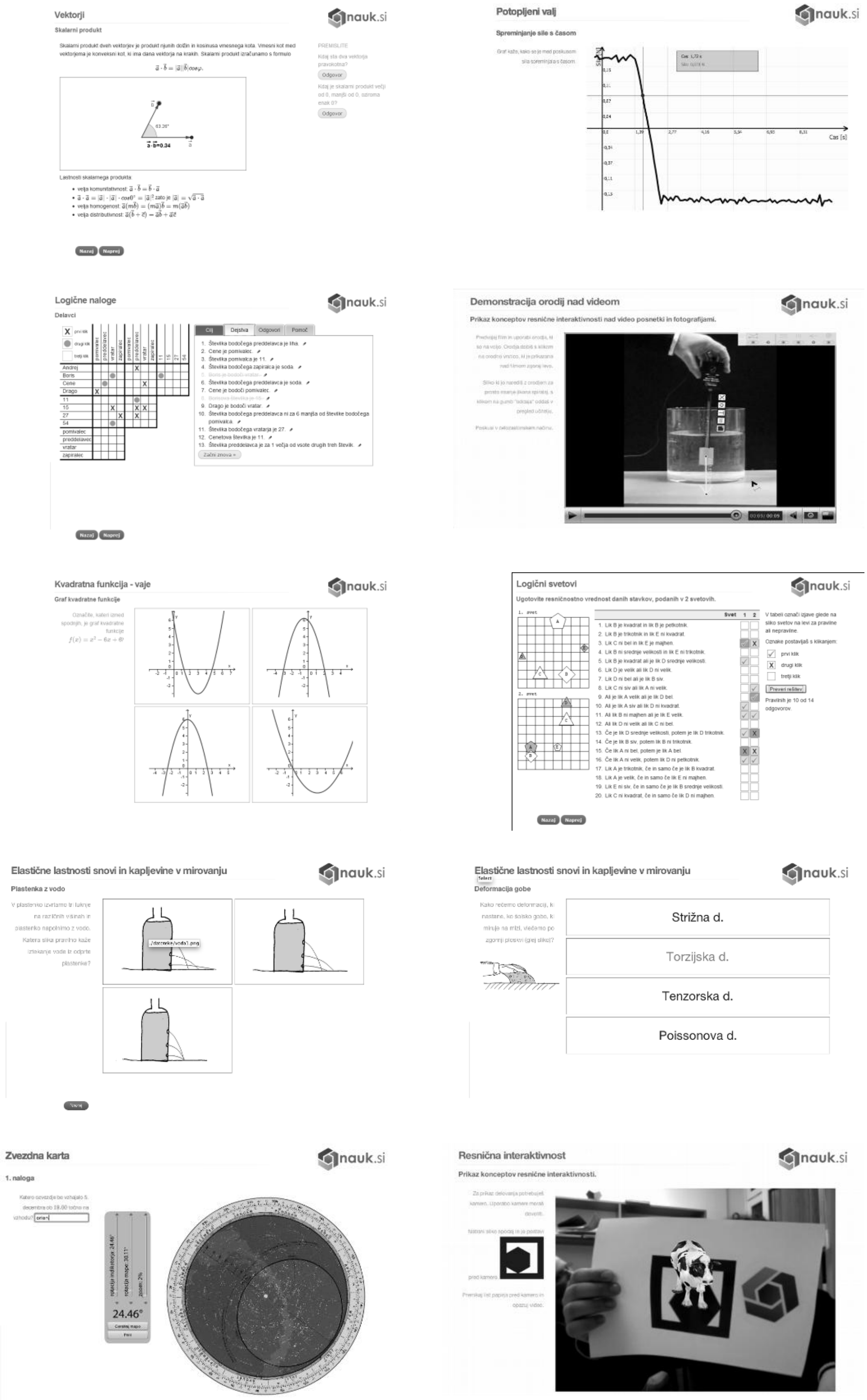

Figure 7: The really interactive learning by using NAUK e-learning tools and concepts.

One of the most important features of the current approach is that every interactive element (quiz element, button and tool) triggers a transition to the next slide, which is selected automatically according to the current context of the learning process. Probably the simplest example of this concept is the following. A learner that makes a mistake by answering a question incorrectly is given a customized response and can be allowed (if this mistake is not too big) to automatically proceed to the next slide, or is returned to another question, which is slightly modified (eased or changed in such a way that the learner will be forced to use the same learning process to solve the modified problem). Thus, the learning path is nonlinear.

FURTHER WORK

Informal interviews with many teachers as well as the first reactions of users have shown that the described concepts and solutions form a good approach that will provide higher quality of teaching and learning. The NAUK project group determined that it is wise to invest further efforts in upgrading demonstrated concepts. Therefore, the project group intends to build a web based community, where it will be possible to give opinions and comments on existing materials and to grade them.

Since good ICT solutions in the field of education spread quickly (Beyond Textbooks, 2009), all members involved in NAUK projects hope for the success of the presented solutions and concepts, but are also aware that further development in this area relies heavily on the satisfaction of the end-users - the students.

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LIVING ANIMALS IN THE CLASSROOM – A STUDY ON LEARNING SUCCESS, EXPERIMENTAL COMPETENCY AND SITUATIONAL EMOTIONS

Eberhard Hummel

Univ Education Heidelberg, Biology and Didactis, INF 561-2, D-69120 Heidelberg, Germany

hummel@ph-heidelberg.de

Christoph Randler

Univ Education Heidelberg, Biology and Didactis, INF 561-2, D-69120 Heidelberg, Germany

randler@ph-heidelberg.de

ABSTRACT

Living animals are supposed to be very motivating for school pupils. Based on previous results of studies on the effectiveness of educational methods in the field of interest research, we assume that many animal species are suited well for education processes, but there is a surprising lack of empirical studies. Most published work is based on the study of Düker and Tausch (1957) in the 1950s. For this study we developed two treatments with a four-unit experimental class series for fifth and sixth graders (treatment series 1 - living animal, treatment series 2 - film group). Both treatment series just differed in the characteristic “living animal”. We focus on knowledge gain, emotional variables (interest, well-being, boredom, disgust) and experimentation competency. The use of living animals in an experimentally focused class did not necessarily result in an increased knowledge gain; in fact it was lower in the immediate post-test. However, on the long run the differences between the results of the two treatments diminished. Regarding experimental competency both approaches have been effective compared to the control group. Positive emotions (well-being, interest) were higher in the animal treatment, and boredom was lower. We strongly suggest using living animals in the classroom.

Keywords: *biological education; cognitive achievement; experimentation competency, living animals.*

INTRODUCTION

Most educators seem to agree that the use of living animals foster the learning process positively. Nevertheless, there is a lack of theoretical foundation for this acceptance. The few studies published in this field of research show different results. In this study, we focus on the value and the effectiveness of the use of living animals in a middle school classroom. Specifically, we look at the gain in knowledge and in experimentation competency, as well as at emotional variables such as interest, well-being and boredom and disgust. Therefore, we first give a short overview over the theoretical background of the study.

1.1. Theoretical background

The theoretical background of this study is located within the framework of self-determination theory as explicated by Deci and Ryan (1985). These authors identify three basic needs in learning: experiencing competency, autonomy and social relatedness. Educational interventions, therefore, should take these basic findings into account. We therefore based our two different treatments on these suggestions, and developed two alternative educational interventions that both were based onto this theory using hands-on experimental material (Randler & Hulde, 2007).

Emotional aspects of learning

According to Pintrich, Marx and Boyle (1993) learning processes could not barely be defined just as „cold cognition“ and additional factors such as cognitive, affective and social variables have to be taken into consideration, too. Some psychological studies emphasise the significance of emotions in both learning and performance situations. However, until recently, emotions have not been sufficiently attended to in classroom instruction in general (Gläser-Zikuda, Fuß, Laukenmann, Metz & Randler, 2005; Randler, 2009), and have been rather neglected in research in biology education. Hereby, positive emotions were supposed to positively influence learning and achievement processes and negative ones do the contrary (Laukenmann, Bleicher, Fuß, Gläser-Zikuda, Mayring & Rhöneck, 2003; Pekrun, Götz, Titz & Perry, 2002). Our study is based on a concept that distinguishes between current situational emotions and biographically developed and enduring "trait"- emotions (Randler & Bogner, 2007; Ulrich & Mayring 1992). In the focus of this present study were the situational ("state") emotions because they could be directly linked to the content of the respective educational unit and the respective tests on achievement. The concept of "state"-variables means that pupils responded immediately after the respective lessons.

Cognitive achievement in animal classes

In nearly every text book on biology teaching, the worth and value of living animals in the classroom is unquestioned, however, this far-reaching conclusions have been only rarely under thorough study and this assumption becomes less valid if empirical evidence is required. There is a surprising lack of empirical studies currently dealing with the effects of living animals on learning outcomes and most of the published work, especially during the 1960ies until the 1980ies is based on a flawed methodological design. Most of these suggestions are based on the pioneering work of Düker and Tausch (1957) in the 1950ies. In more recent work, e.g. Morgan (1992) found an interaction between the level of involvement (which could be considered as some kind of measure of motivation) and learning outcome in a treatment based on snakes. That is, the more direct contact with the snakes existed, the lower was the retention and learning outcome. Sherwood, Rallis and Stone (1989) found no differences in learning outcome between living insects and preserved specimen during an exhibition at a zoo, but these authors revealed differences in affective variables where living animals were assessed as more motivating by the pupils. Killermann (1996) reported a higher cognitive achievement when using living animals in secondary school pupils by comparing living invertebrates with slide presentation. In primary school pupils, Randler, Ilg and Kern (2005) showed a higher learning and retention effect when pupils who participated in lessons about amphibian species also encountered these species in a natural setting during migration, while differences in interest, well-being, boredom and anxiety did not exist between the indoor and outdoor group.

Experimentation competency

Recently, effort has been put into the measurement of competency, especially with a focus on experimentation (Neber & Anton, 2008; Phan, 2008). In particular, the focus lies on the competencies of forming hypotheses, planning experiments and analysing data. These competencies were selected because they are crucial to experimentation as problem solving, according to the SDDS model (Klahr, 2000; Hammann, Phan, Ehmer & Grimm, 2008).

MATERIALS AND METHODS

The study took place in the second half of the school year in 2009. 516 pupils (244 boys and 272 girls) from middle schools participated in this study (living animal-group: n=225; film-group: n=172; control-group: n=119). Pupils were 5th and 6th graders (10 to 13 years). The

German school system in Baden-Württemberg separates pupils at the end of the 4th grade into three different stratifications according to their cognitive abilities. In our study, pupils from the highest stratification (in German "Gymnasium"), and from the middle stratification (in German "Realschule") participated in this study.

Treatments

We developed four different treatments aimed at enhancing experimentation competency and cognitive achievement. Treatment 1-3 (mouse, woodlice, and snail) differed between the treatment groups while the fourth treatment was identical (Figure 1). Therefore, it served as a kind of internal control to assess whether both treatment groups are indeed comparable. The fourth unit had no influence on the experimentation competency measure and the post- and follow-up test (see Procedure for details). In all treatments, pupils worked together in groups of 3-4 and made observations on their own. Therefore, a detailed booklet was developed guiding the pupils through their learning process. In the living animal treatment, pupils carried out all experiments on their own, while in the film treatment, the pupils watched a film especially designed for this unit. For example, in the mouse treatment, pupils observe a house mouse (*Mus musculus f. domesticus*) in an open field test. There are three jobs to do: one pupil is keeping the time, another one is observing the mouse and every five seconds reports the exact position on the field, while the third pupil notes the results on a sheet. After some time, the positions are changes so that every pupil experiences all of the three jobs. The difference between the treatments is simply the presence of a mouse. In the living animal treatment, the pupils observe the living mouse, in the film treatment, the pupils observe a mouse on a film (without any commentaries), so the situation is nearly identical and the pedagogical preconditions (group-based, hands-on work) are similar. We feel that is a rather strict experimental approach reaching farther beyond most previous approaches tackling this question. The fourth unit is concerned with bird flight and contains hands-on experiments. We have included this fourth unit, because we suppose that both treatment groups should score equally to the identical educational treatment (bird flight), which, in turn, provides evidence for the fact that both treatment groups are comparable.

To minimize the influence of the teachers, they got detailed instructions for the implementation of each lesson. In addition, the students got a multi-page workbook for each unit to ensure an additional and largely self-directed process. The workbooks are nearly the same in both groups (experimental and control), and differed only in the instructions for the experimental procedure. Everything else was equal: the instructions for

a) the identification phase of the hypotheses, for the experimental planning
b) the analysis and interpretation of data
c) general guidance on the conduct of an experiment (e.g., control of variables, varying one factor, the role of an control-experiment)
d) the observation of animal's external features, which were performed in advance of the experiment to accustom the students to the animals and to show how they have to deal with them.

The initial problems (inquiry-based of each lesson) were illustrated on slides, which were identical in both groups, too.

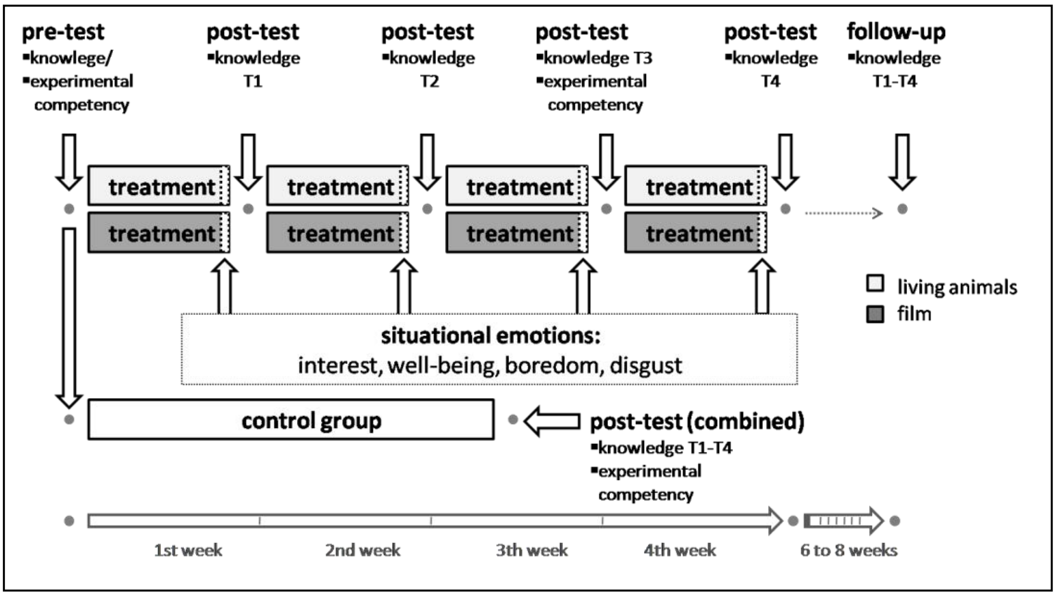

Fig. 1. Overview over the experimentation procedure, the measurements, and the treatment and control groups.

Measurements

We used a battery of tests to assess the different constructs of our work (Figure 1). Experimentation competency was measured using a paper and pencil test (Cronbach's alpha = 0.619; 27 Items) Cognitive achievement was measured using a pre-/post-test and follow-up test design, also based on paper-pencil-tests. Situational emotions were assessed immediately after the respective treatment units. Here, we used a short scale that measured the constructs interest, well-being, and boredom (Randler, 2009) and a one-item measure of disgust. In addition, the students were asked the following teaching relevant questions (Mixed methodology; Mayring et. al. 2007)

1. What did you like best about the lesson?
2. What did you dislike about the lesson?
3. What is of interest to you, right now?

Procedure

To prevent order effects, the treatments were distributed at random, i.e. one class started with woodlice, another with snails, and the third with the mouse unit. Every week, one treatment was applied. The bird flight unit was always used as fourth unit because it served as some kind of control. This balanced design ensures that there are no order effects of the treatments. Experimentation competency and pre-test were carried out before the educational unit started in all three treatment groups (control group, living animal group, film group). After every unit (mouse, woodlice, snail, bird flight), we assessed the situational emotions and after one day up to one week, we assessed the cognitive achievement in the treatment groups. In the control group, post-tests were combined because the pupils received not educational intervention. The termination of the post-test reflected the fourth treatment post-test. After the three first treatments (which were randomized to achieve a balanced design), and before the bird flight unit started, we again assessed experimentation competency in both treatments. The follow-up test was written with a delay of six to eight weeks in both treatment groups.

Statistical analyses

We used a series of general linear models (GLM) to calculate the effects of gender and treatment (and the interaction term between both) by using prior knowledge as a covariate to account for individual differences in prior knowledge. The calculations were carried out in different ways: first, we compared the treatment group (film/living animals) versus our control group, and second, we compared both treatments (film vs. living animals) with each other. Experimentation competency was compared without any transformation of the data, while the cognitive achievement tests were z-scored to account for differences in the respective tests. We assessed knowledge by immediate post-tests in the four units, woodlice, snail, mouse and bird flight. Each of these four immediate post-tests was z-transformed to achieve a mean of 0 and a standard deviation of 1. Afterwards, the post-test scores of woodlice, snail and mouse were added to get an overall post-test score with an equal weighting of every unit. In the follow-up test, the procedure was similar. The bird flight unit was compared separately because it was identical in both treatments to serve as some kind of control. For the comparison of the emotional values we used a T-test.

Out of the responses of the qualitative survey we formed different higher level structures according to Mayring 2000 and converted them into values to facilitate a mixed methodologies approach (Mayring 2001). For the calculation we used the Chi-square-test (X^2-test).

RESULTS

First, we found differences between the treatment and the control group in experimentation competency, suggesting that both treatments (living animals/film) increased the competency (see Figure 2). Pre-treatment experimental competency had an expected significant influence on post-treatment experimental competency ($F_{1,460}$=87.574, p<0.001, partial η^2=0.16). Gender also revealed a significant influence with girls achieving a higher experimental competency (F=$_{1,460}$=17.609, p<0.001, partial η^2=0.03). Finally, treatment vs. control showed a significant influence ($F_{1,460}$=30.716, p<0.001, partial η^2=0.06). However, there were no differences between the two treatments, i.e. living animals as well as films both could be used to increase experimentation competency.

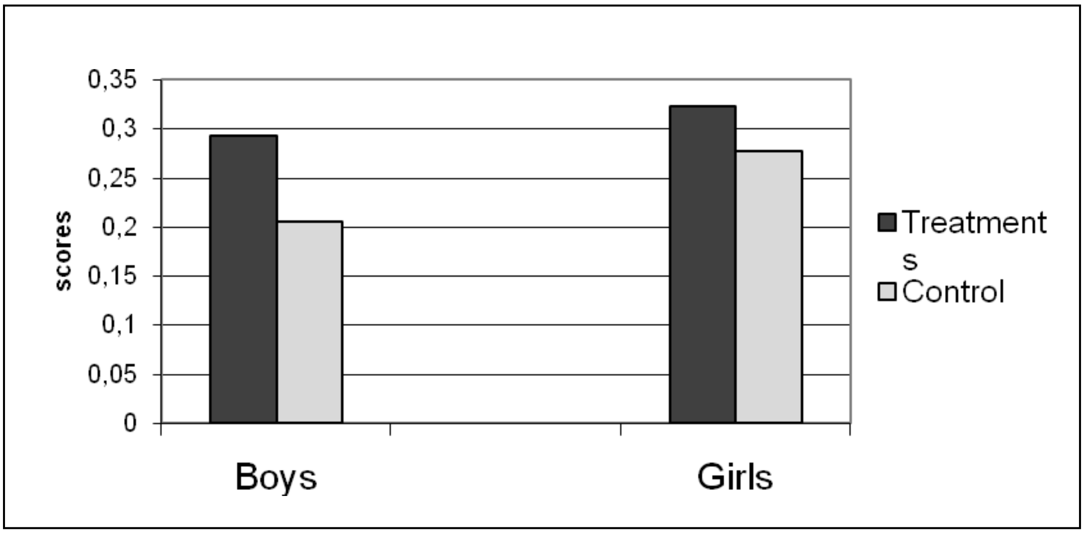

Figure 2. Comparison of experimentation competency of both treatments with the control group, estimated marginal means from a GLM using pre-experimentation competency as co-variate.

Second, there was a significant difference and a high effect size of this difference when comparing cognitive achievement between the treatments and the control group. The pupils acquired a substantial knowledge in the post-test compared to a group without treatment. Pre-treatment knowledge had an expected significant influence on post-treatment knowledge

($F_{1,486}$=72.538, p<0.001, partial η^2=0.13). Treatment vs. control also showed a significant influence with a high effect size ($F_{1,486}$=797.893, p<0.001, partial η^2=0.62).

However, there was a significant difference between both treatments and a gender effect based on a multivariate GLM. Thus, the film group acquired a significantly higher knowledge than the group with living animals (Wilk's λ=0.942, F=10.76, p<0.001, partial η^2=0.05). Further, girls seem to learn better than boys (gender: Wilk's λ =0.959, F=7.524, p=0.001, partial η^2=0.04), while the interaction was not significant. As expected, the pre-test scores also had a significant influence (Wilk's λ =0.850, F=30.645, p<0.001, partial η^2=0.15). Table 1 depicts the subsequent univariate GLMs (see also Figure 3). The difference between the treatments was lower in retention test, as was the effect size (see Table 1).

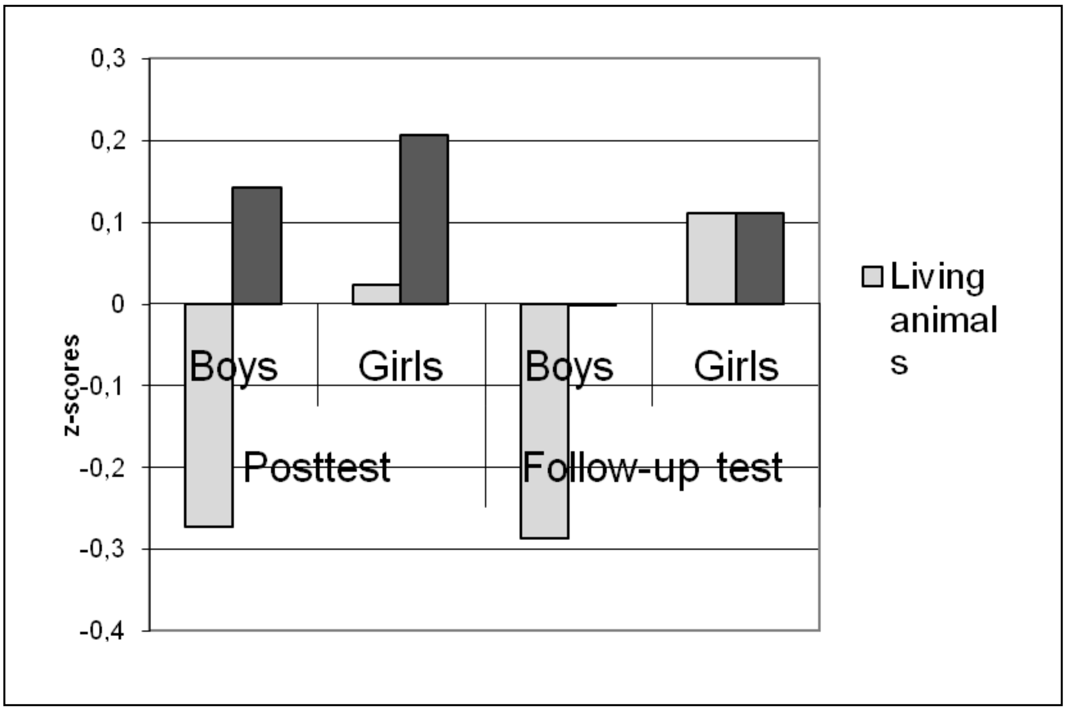

Figure 3. Comparison of the cognitive achievement in both treatments.

In detail, there were no differences between both treatments in the woodlice group, but pupils performed better in the film group, both in the unit snails (Wilks' λ =0.974, F=4.451, p=0.012, η^2=0.02) and mouse (Wilks' λ =0.958, F=7.420[a], p=0.001, η^2=0.04).

As expected, both groups scored equally in the bird flight unit (Wilk's λ = 0.997, F=0.441, p=0.644, η^2=0.00), which was similar in both treatments, and, therefore, shows that both treatment groups are comparable.

Third, we found differences in the emotional variables interest, well-being and boredom (Figure 4). Pupils in the living animal treatment scored interest and well-being significantly higher and boredom significantly lower than pupils from the film treatment.

Table 1. Univariate GLMs using post-test or follow-up test as dependent variable, gender, treatment as fixed factors, and pre-test scores as co-variate.

Source of variation	Dependent variable	Type III sum of squares	df	Mean of squares	F	P	Partial η^2
Corrected Model	Posttest	33.330[a]	4	8.332	23.191	.000	.210
	Follow-up	20.281[b]	4	5.070	12.544	.000	.126
Konstanter Term	Posttest	.266	1	.266	.740	.390	.002
	Follow-up	.077	1	.077	.191	.663	.001
Pretest	Posttest	21.524	1	21.524	59.904	.000	.146
	Follow-up	9.728	1	9.728	24.068	.000	.065
Gender	Posttest	2.789	1	2.789	7.762	.006	.022
	Follow-up	5.621	1	5.621	13.908	.000	.038
Treatment (film vs. living animals)	Posttest	7.738	1	7.738	21.536	.000	.058
	Follow-up	1.780	1	1.780	4.403	.037	.012
Interaction gender * treatment	Posttest	1.159	1	1.159	3.227	.073	.009
	Follow-up	1.772	1	1.772	4.384	.037	.012
Error	Posttest	125.397	349	.359			
	Follow-up	141.061	349	.404			
Total	Posttest	158.800	354				
	Follow-up	161.416	354				
Corrected total variation	Posttest	158.727	353				
	Follow-up	161.342	353				

[a]. R^2 = .210 (corrected R^2= .201)

[b]. R^2 = .126 (corrected R^2 = .116)

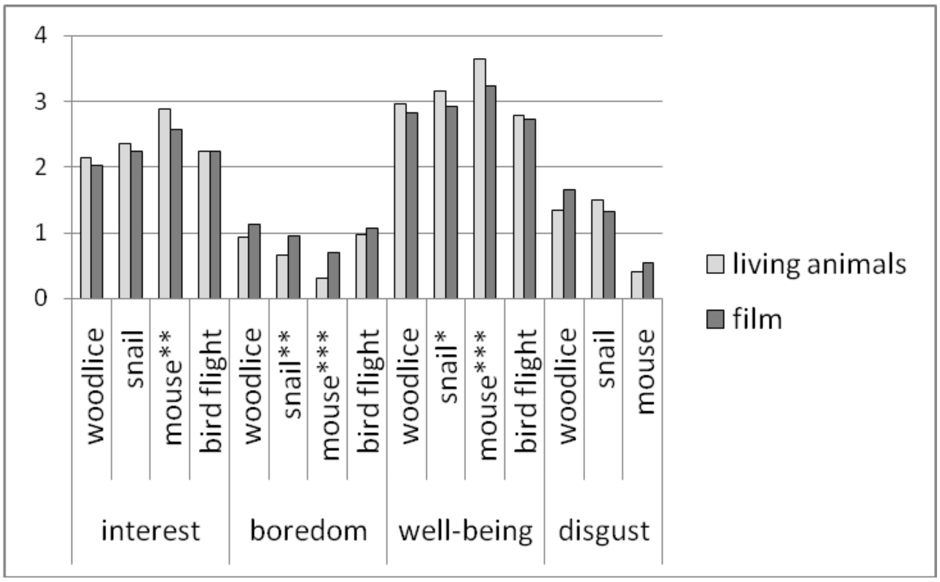

Fig. 4. Comparison of two different treatments in emotional variables. *p<0.05, **p<0.01, ***p<0.001. Scale from 0 – 4.

Fourth, we found negative correlations between boredom and disgust and the cognitive achievement tests. Pupils experiencing higher boredom and higher disgust scored significantly lower in the post-test and the follow-up test (boredom and post-test r=-0.100, p=0.047; boredom and follow-up test: r=-0.115 p=0.028; disgust and post-test r=-0.103, p=0.043; disgust and follow-up test: r=-0.111, p=0.033).

Fifth, the results of the qualitative part of the survey could largely confirm the findings of the paper and pencil test. On the basis of this qualitative approach, it has also been shown, that the pupils of the living animal group more frequently mentioned animal specific fields of interests beyond the contents of the lesson, like living conditions, habitat or way of life (snail: p<.000; mouse: p<.000; woodlice n.s.; Figure 5; table 2).

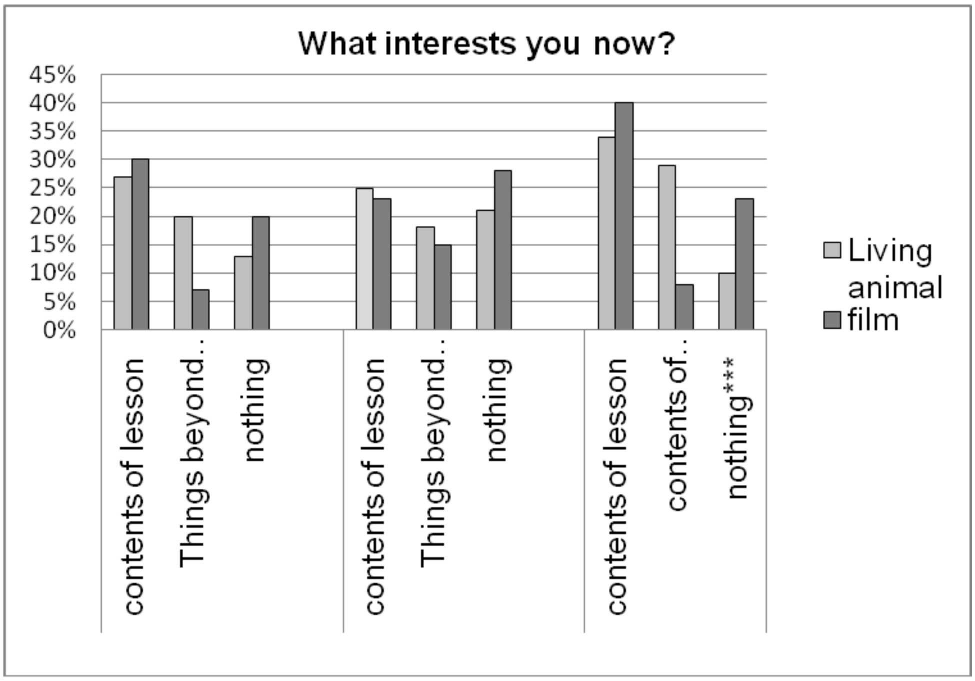

Figure 5. Qualitative approach - differences between the pupils animal specific interests after the lesson.

Table 2. Animal specific fields of interests after the lesson

Snail	Mouse	Woodlice
Way of life***	Way of life **	habitat*
Reproduction and offspring	Maximum age **	Reproduction and offspring**
	Reproduction and offspring*	

DISCUSSION

The results of our study are encouraging since they show that the use of living animals in the classroom is of benefit for the pupils. The experimental treatments both enhanced the experimentation competency, a fact, that has been rarely demonstrated in any other study in biological education. In fact, we are currently only at the start of measuring competencies in field studies (see, e. g. Hammann *et al*., 2008). Therefore it is necessary to develop these measurement instruments further. Nevertheless, our results are encouraging since they show that it is possible to increase experimentation competency at all, albeit effect sizes were low. As we used a control group filling in the same questionnaires, and this group scored lower, we can assure that the increase in experimentation competency is not an artifact or a result of repeated testing but a significant treatment effect. As both treatments produced a similar effect in experimentation competency, we concluded that both educational treatments are equally suited for lessons with the aim to increase this competency.

Cognitive achievement, however, was better in the film treatment, suggesting that some factors may detract pupils from learning. In the end, however, the difference between both treatment groups diminished. Pupils may be irrigated by the living animals that may evoke disgust (in a negative manner) or interest in a positive manner. Also, handling animals might be more difficult than just watching videos. This could be – at least partially – be explained by the cognitive load theory (Sweller, van Merrienboer & Paas, 1998). Pupils in the treatment with living animals were confronted with new learning objects (animals) and they are not prepared to this new task, which, in turn, has an effect on learning and retention. So it might be easier for pupils to focus on the tasks in the film group. Nevertheless, we used the same educational methods (group-based learning) in both treatments, and both groups had to work on their own, and both did the same kind of analyses using similar working sheets. Therefore, the differences should be clearly ascribed to the variable living animals. Nevertheless there are some points strongly argue for the use of living animals in lessons. The values of the emotional variables were largely higher in the living animal group. It has also been shown, that the pupils of the living animal group more frequently developed further animal specific questions beyond the contents of the lesson. An important aim of biological education. Moreover, in the follow-up tests after 6 to 8 weeks the differences in the subject specific knowledge between the two groups were slightly lower than in the post-test. Here it would be interesting to measure again after a longer period. Perhaps the differences between both groups would be completely balanced.

Our study has some strength that should be emphasized: First, we used an additional intra-individual control group, the bird flight treatment that was similar in both treatment groups. As both treatment groups achieved similar cognitive scores and scored the emotions also similar, we concluded that there were no differences between both treatment groups. Of course, the person of the teacher may have an significant influence on learning and retention, we can exclude such effects because of the high sample size. Also, Randler and Bogner (2008, 2009) showed that typical treatment-control group comparisons with different teachers might as good as related groups based on a similar teacher. Second, we used a sophisticated design to account for order effects. Assume, for example, that one of the three specific treatments would be best to be placed at the beginning or the end of the intervention;

this might have caused all the effects. As we did not find any order effects in our treatments, we can exclude these effects.

CONCLUSION

The results of this study are encouraging in different ways. First, we found no differences in experimentation competency between both treatments, clearly suggesting that living animals can be used in such educational units because they evoke positive emotions. Further, living animals show a positive emotional effect. It is likely that the students using living animals develop more questions that go beyond the contents of the lesson. To substantiate this finding more research is needed. In this case, investigating the effects of other species would be interesting.

Although the cognitive achievement was lower in the living animal group, we suggest that the higher emotional values, the development of further questions and also the reduction in cognitive content should be taken as an advantage to use animals in the classroom.

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EDUCATIONAL REFORMS AS PARADIGM SHIFTS: UTILIZING KUHNIAN LENSES TO UNDERSTAND TEACHER RESISTANCE TO EDUCATIONAL REFORM

Serhat Irez

Marmara University

sirez@marmara.edu.tr

Cigdem Han

Marmara University

cigdem.han@marmara.edu.tr

ABSTRACT

Research acknowledges that reform efforts in education often face with a resistance, particularly on the part of teachers. This study attempts to get to a better understanding of the reasons of resistance to change on the teachers' side through utilizing the structure of scientific revolutions as described by Thomas Kuhn as an analogy. To this end, a recent curriculum reform in science education in Turkey is taken as a case and the previous and new biology curricula are analyzed comparing their emphasis, approaches to the nature of scientific knowledge, theories of learning, models for teaching and approaches to the assessment of learning. This analysis revealed that the curriculum reform experienced in Turkey has introduced a new world for teachers, which is fundamentally different from the previous one. To this end, the study discusses that understanding and applying the new paradigm introduced by the new curriculum could be one of the major barriers that teachers face in the implementation of the curriculum reform.

Keywords: *Educational reform, paradigm shift, teacher resistance*

INTRODUCTION

The main aim of any reform in education is to improve educational programs and practices which will, in turn, assist to meet overall objectives of education in more effective ways (Fullan, 1991). Change is a difficult process, because, educational change of any significance involves changes in organizational structures, communications, resource allocation, practices, and beliefs and attitudes (Avenstrup, 2007). Research acknowledges that reform efforts often face with a resistance, particularly on the part of teaching staff. Current literature on educational research usually attributes to external factors such as entrance examinations at different levels of education, parental pressure and top-down nature of reforms (Könings, Brand-Gruel, & Van Merrienboer, 2007; Wendy, 1991) and internal factors such as lack of training (Könings, Brand-Gruwel, & Van Merrienboer, 2007), leadership (Roehrig, Kruse &, Kernl, 2007) and communication (Wendy, 1991) as sources of the resistance to change on the teachers' side. Although this categorization of the sources of resistance to educational change on teachers' side is important and helpful in understanding the dynamics of educational change, multiple perspectives is needed to capture the nature and aspects of this complexity (Anderson, & Helms, 2001; Schmidt & White, 2004).

In this study, we assumed that the nature of scientific revolutions as described by Thomas Kuhn provides one of the possible ways to analyze the nature of large-scale educational reforms and the complexity of the process. Further, we believe that using such an analogy, we could get to a better understanding of the reasons of resistance to change on the teachers' side. Briefly, Kuhn describes progress in science in terms of paradigmatic shift. One important aspect of Kuhn's paradigms is that the paradigms are incommensurable—that is, it is not possible to understand one paradigm through the conceptual framework and terminology of another rival paradigm. In other words, rival paradigms describe different worlds. The related question here is that what happens to a scientist that has experienced a paradigm shift in the field? According to Kuhn, when the “normal scientist” is confronted with evidence that the new paradigm may be mistaken, he or she tends to ignore that evidence and sticks with it. There may be many reasons for this conservatism, being educated in the new paradigm, having established themselves in it, perceived difficulty of learning a new conceptual framework, etc. This conservatism is exactly what we utilized in our study.

In one sense, large-scale educational reforms resemble scientific revolutions. As in paradigm shifts, large scale educational reforms bring new conceptual frameworks, introduce new educational aims and view on how people learn, require to adopt new teaching and assessment approaches and materials, etc. It is expected from the implementers of the reform, that is teaching staff, to comprehend and reflect the new requirements of the reform in their practice. However, this is not an easy task. Many teachers were educated with the conceptual framework and norms of the previous educational approach, as the normal scientist working in the old paradigm did before the paradigm shift in Kuhn’s scientific revolutions. We assume that it is difficult for or cannot be expected from a practicing teacher, as for the normal scientist experiencing a paradigm shift, to comprehend and adopt himself/herself to the new world that is introduced by the educational reform.

With this conceptual framework and in order to exemplify how a large scale educational reform introduces a new world for teachers, this study analyzed a curriculum reform recently taken place in secondary biology education in Turkey. The curriculum is the heart of education and all else in the system is derived from this: how learners should be assessed, how teachers should be trained and develop, what textbooks and other learning support materials should be like, how schools and the educational system should be organized and managed, and the allocation of resources necessary for the system (Avenstrup, 2007).

Turkey has one of the biggest and youngest populations in Europe; therefore, education has been and continues to be of critical importance to the nation’s social, political and economic development. Like many governments around the world, the Turkish government is aware of the importance of preparing its citizens for the challenges of the new century, and has introduced many reforms at various levels of education in the last ten years. The latest of these reform efforts took place in the secondary education. With this movement, both the structure and content of the secondary education was targeted. The length of the secondary education, which was three years, has become four years. The content and philosophy of secondary education has also targeted. In secondary science, for example, new science curricula and curriculum materials have been introduced. This new curricula have presented new aims, learning and teaching approach, and method of assessment for secondary science teaching.

METHODOLOGICAL AND ANALYTICAL FRAMEWORK

A qualitative oriented approach was employed and Ethnographic Content Analysis (ECA) (Altheide, 1996) was chosen as an appropriate methodological framework for this particular research. In this framework, the method of reviewing started with reading and coding previous and new biology curricula in the light of previously determined themes (curriculum emphasis, assessment approach, etc.). However, new themes were included as they emerged in this constant comparison of documents (for example, the nature of scientific knowledge).

RESULTS

The analysis of the two biology curricula was conducted by comparing the approaches of these documents to five major themes. These were the *curriculum's emphasis*, *the nature of scientific knowledge* depicted in the curriculum, the *theory of learning* that the curriculum utilizes, *model of teaching* that the curriculum suggests and, the curriculum's approach to *the assessment of learning.* Analyses conducted in these five themes revealed major differences in the approaches of the two curricula.

Curriculum Emphasis

One of the important steps in curriculum development process is the identification of coherent set of messages to the student about science (Roberts, 1982). Because, Roberts argues, such messages *'constitute objectives which go beyond learning the facts, principles, laws, and theories of the subject matter itself – objectives which provide answers to the student question: "Why am I learning this?"'* (p. 245). This answer to this question reflects the emphasis on what is valued and desired in the curriculum. Roberts calls this '*curriculum emphasis*' and, discusses and describes seven different emphases utilized by curriculum developers in the last century. He argues that each emphasis, naturally, shapes the content and the structure of the curriculum.

The framework and classification defined by Roberts was used in analysing the differences regarding the emphases of both curricula. To this end, the overall objective of the previous biology curriculum emerged as;

'... to help individuals who will constitute the science-society to acquire scientific problem solving skills for the problems they may encounter in their everyday life ...' (Ministry of National Education [MNE], 1998, p.131).

This overall objective was followed by a list of attainment targets. *'Learning the general structure of living things'* was, somewhat inconsistent with the overall objective, on the top of the list. This was followed by '*learning about and caring environment'* and *'developing habits needed for a healthy life'.* Parallel to these attainment targets, the previous curriculum put emphasis on the learning of biology content and developing skills to solve everyday problems utilizing a scientific approach**.**

In light of this analysis, the previous curriculum's approach falls into the *'Correct Explanations'* and the *'Everyday Coping'* emphasis in Roberts's (1982) framework. Roberts argues that the *Correct Explanations* emphasis stresses science products that are accepted by scientific community. This emphasis gives the messages *'master now, question later'* (Ibid.). The *Everyday Coping* emphasis, on the other hand, declares that science is an important means for understanding and controlling one's environment (Ibid).

The overall objective, or the 'vision' as it is called, of the new curriculum is stated as;

’... to educate scientifically literate individuals that understand the nature of science… appreciate the necessity of learning biology… possess adequate cognitive conceptual frameworks regarding biological concepts… comprehend the relationship between science-society-technology… approach problems with the principles of scientific inquiry.’ (MNE, 2007, p.3).

The structure and content of the new curriculum were shaped in order to achieve the overall objective. To this end, the new curriculum targets developing skills and attitudes related to the aforementioned overall objective (that is educating scientifically literate citizens) as well as developing knowledge of biology. The attainment targets are divided into three groups in the new curriculum. These are; a) *Science-Technology-Society-Environment,* b) *Communication Skills, Attitudes and Values*, c) *Scientific Inquiry and Science Process Skills*.

Considering such an overall objective and related attainment targets, the new curriculum’s emphasis bears the aspects of three emphases in Roberts’s (1982) classification. These are the *‘Structure of Science*’ emphasis, the *‘Science, Technology, and Decisions’* emphasis and, the *‘Scientific Skill Development’* emphasis.

The new curriculum’s emphasis includes the ‘Structure of Science’ emphasis as it stresses and gives messages about how science functions intellectually in its growth and development (Roberts, 1982). The new curriculum targets student understanding on the nature and status of scientific knowledge, the interplay between evidence and theory, the role of models for explaining natural phenomena, the subjective nature of science, etc. Unlike the previous curriculum’s emphasis on ‘Everyday Coping’, the new curriculum puts an emphasis on the limits of science in coping with practical affairs. The new curriculum also stresses the development of scientific process skills as opposed to learning the products or content of science, which were emphasized in the previous curriculum.

To conclude, as discussed above, the two biology curricula have radically different emphases regarding the objective of biology education at secondary level. This difference in the emphases shows that these two curricula have different worldviews. Consistent with their difference in worldviews, analysis revealed that the curricula also have different understandings about the nature of science and scientific knowledge.

NATURE OF SCIENTIFIC KNOWLEDGE

The analysis revealed that the previous and new biology curricula have radically different perspectives with regard to their perceptions of the nature of scientific knowledge. While the previous biology curriculum presented the nature of knowledge from a positivist perspective, the new curriculum presents a constructivist perspective. Science, for example, was defined as *‘cumulative knowledge gathered through observations and experiments’* (MNE, 1998, p.139) in the previous biology curriculum. What is immediately evident from this description is an introduction of science as “body of knowledge”. The view that science represents a body of knowledge was implicitly supported in the following units by portraying biology as a collection of facts. For example in the unit titled *Views about the Origins of Life* in which the theory of evolution was introduced, the curriculum stated that

‘... the factual knowledge in biology was presented in the earlier sections, this section, however, presents interpretations of these.’ (MNE, 1998, p.211).

Such a description of science and scientific knowledge also underpinned another view that there is an existing truth or reality out there and science represents the way of reaching that reality or truth. This view portrayed science as a process of discovering (or collecting, exploring) what is out there. The previous curriculum presented this process as “the” scientific method. The scientific method, according to the previous curriculum, was a step-wise and universal procedure in science. The previous curriculum’s expectations from the students were;

- *Write and/or articulate the steps of the scientific method.*
- *Decide whether the steps of the scientific method were used in a given example of a scientific investigation.*
- *Write and/or articulate that it is required to follow the steps of the scientific method in the solution of problems in biology*. (MNE, 1998, p.139-140)

The previous curriculum saw following the steps of scientific method as necessary in order to produce and guarantee objective knowledge. Another requirement in obtaining objective knowledge in science, according to the previous curriculum, was the characteristics that scientists should have.

(Students should)

- *Explain the characteristics that a scientist should have.* (MNE, 1998, p.139)

Further, the previous curriculum suggested teachers to ask questions such as “List the characteristics of a scientist” in the assessment of learning. Although the curriculum did not provide a list of these characteristics, the textbooks that used the previous curriculum as the framework did. The research study by Irez (2009) revealed that the secondary biology textbooks reflecting the previous curriculum’s approach provided list of characteristics that a scientist should have. These included characteristics such as being objective, honest, hard-working, determined, logical, and sceptical amongst many others.

On the other hand, science is described from a constructivist perspective in the new biology curriculum. For example, the new curriculum introduces science as a dynamic process of generating "testable and falsifiable" explanations about natural phenomena.

(students should)

- *Develop an understanding that science* [scientific knowledge] *has testable, experimental and falsifiable nature.*
- *Realize that scientific knowledge is tested, corrected or renewed in the light of new evidence.* (MNE, 2007, p.17)

This statement also implies the tentative nature of scientific knowledge. Indeed, in various places, the new curriculum emphasize that all scientific knowledge is subject to change. It views the tentativeness of scientific knowledge from a Kuhnian perspective in that change in science is explained as a paradigmatic shift.

(Students should)

- *Explain the role of evidence, theories and/or paradigms in change of scientific knowledge.*
- *Realize that change in science is continuous and sometimes in the form of paradigmatic shift.* (MNE, 2007, p.17)

In contrast to the previous curriculum, the new curriculum does not present science as an objective enterprise. Instead, it suggests that science and society influence each other and perceives science as a product of society and human-culture.

(Students should)

- *Understand that socio-economic and cultural contexts influence the development of biology.*
- *Understand and gives examples about the contributions of societies that have different historical and cultural pasts to the development of biology.* (MNE, 2007, p.17)

Further, the new curriculum does not claim that scientists should have certain characteristics to ensure objectivity in science; instead, it discusses that subjectivity is natural and expected in science.

(Students should)

- *Realize and discuss the effects of different attitudes and values in science.* (MNE, 2007, p.17)

In sum, the analysis conducted with regard to approaches of the previous and new biology curriculum pointed out a significant difference between their depictions of science and scientific enterprise.

THEORIES OF LEARNING

One of the main themes utilized in the comparison of the previous and the new curriculum was their approaches to learning. Results pointed out that, again, there was a significant difference in the approaches of the two curricula.

Although there was not a separate section in the previous curriculum explaining its orientation to learning, close inspection of the unit plans and the sections where suggestions for teaching were presented gave clues about its approach. “Writing and recalling” of the given information was the constant emphasis in the student attainment targets presented throughout the curriculum.

(Students should)

- *Write and/or recall the important discoveries of the scientists who contributed to biology.* (MNE, 1998, p.139)
- *Write and/or recall the living and non-living factors affecting environment.* (MNE, 1998, p.158)

Such statements, according to Tsai (2002), are typical indicators of traditional learning approach. Further, the statements in *Learning-Teaching* and *Suggestions for Teaching* sections were also parallel and supported to such learning approach.

Students should be provided with examples regarding how they can utilize the scientific method in their daily life. (MNE, 1998, p.140)

Important functions (contributions) of biology should be explained. (MNE, 1998, p.140)

As seen, the structure of these statements itself indicates that teaching was perceived as the transfer of knowledge in which the student is the passive receiver without any cognitive involvement in the learning process.

The new curriculum, in contrast, explicitly states that the knowledge can not be constructed without active cognitive involvement of the learner; that comprehension occurs as a result of adaptation in the conceptual change process; that learning of a new concept depends on previous experiences and knowledge; that learning is socially constructed and; that language and social context play an important role in the construction of knowledge (MNE, 2007). In short learning is explained as a conceptual change process. The student's realization of what s/he knows is an important aspect of the process. Therefore, special attention is paid to and explanations are given about alternative conceptions that students may possess in each topic.

This orientation to learning is apparent and verbalized in all attainment targets throughout the curriculum.

(Students should)

- *Realize the limits of the technological development process, its resources and the possible effects of technological applications.*
- *Develop an understanding about the relationship between Science-Society-Environment.* (MNE, 2007, p.17)

The structure of these statements clearly shows the difference in the approaches of the previous and new biology curricula regarding learning. While learning was depicted as a passive process in the previous curriculum, it is perceived as an active process in which the learner's involvement in the construction of knowledge is required.

MODELS FOR TEACHING

It is natural to think that a curriculum's teaching approach is linked to the way it perceives learning. It is because the learning environment should be designed in accordance with how and what students should learn. The analysis of the two curriculum documents revealed that, as expected, they presented teaching approaches that are compatible with their learning orientations.

The role of the teacher in the previous biology curriculum was described as providing knowledge for students in line with its objectives which were presented earlier. Following is an example that gives clues about the previous curriculum's teaching approach.

The non-living factors effecting living things are explained as light, temperature, climate, minerals, water, and pH. (MNE, 1998,Unit 'The Environment and Living Things', p. 159)

As it is exemplified in this statement, what was expected from the teacher was to present (or transfer) certain, absolute and true knowledge to students. According to Tsai (2002) presenting the nature of scientific knowledge in such an absolutist manner is an important indication of traditional teaching orientation. Such statements were abundant in the previous curriculum, as the following is one another example.

The discovery of the cell is taught by narration and experiments. (MNE, 1998, Unit 'The Cell', p. 151)

Parallel to its learning orientation, the new curriculum differs from the previous one in terms of its approach to teaching biology. To this end, the required teacher competencies to meet the objectives of learning are described as follows in the new curriculum:

... constructivists teachers who realize the importance and emphasize the role of student-centred activities, realize individual differences but not disregard social skills, possess an

assessment approach that focuses on the assessment of learning process as well as products... (MNE, 2007, p.17)

Throughout the document, the new curriculum explicitly and implicitly stresses that, in learning process, students should be active and involved in the construction of knowledge. The overall role of the teacher is to guide learning.

ASSESSMENT OF LEARNING

The last theme in the comparison of the two curricula was about their approach in the assessment of learning. The analysis revealed that there were remarkable differences between the approaches.

In line with its approach to learning and teaching, the previous biology curriculum suggested a teacher-centred, summative assessment approach which gives priority to the assessment of learning at the knowledge and/or comprehension levels in Bloom's (1956) taxonomy. The curriculum's approach to the assessment of learning and its suggestions about the ways of assessment were detailed in separate sections at the end of each unit. For instance, about the assessment approach regarding the learning outcomes of the first unit, the curriculum stated;

Exams can be utilized in the assessment of learning outcomes at the end of this unit. (MNE, 1998, Unit 'Biology as a Scientific Discipline', p. 143)

As this statement implies, the aim of assessment was checking whether the learning targets have been met in a traditional way. Analysis of the example questions provided further supported this finding.

How many different types of muscle tissues exist in the body? Write the differences. (MNE, 1998,Unit 'Tissues', p. 169)

The assessment tools suggested in the previous curriculum included classical written exams, multiple choice tests, fill-in-the-blank and true or false questions. This approach and tools for assessment is criticized in the new curriculum.

The new biology curriculum stresses that the assessment of learning process and the skills and attitudes developed in the process is as important as the products (MNE, 2007). It emphasizes that;

Today, along with fundamental knowledge, skills and attitudes, students also need to develop knowledge, skills and attitudes such as critical thinking, creative thinking, problem solving, inquiry, collaboration, scientific reasoning and interpretation, effective communication etc. (MNE, 2007, p. 7)

The new curriculum puts forward that performance (alternative) assessment approaches and tools are needed in order to assess students' performance and progress in these domains. The new curriculum asserts that the impact of this assessment approach can be further strengthened if it is constructed in a way that engages students with meta-cognitive activities and related to real life (MNE, 2007). The assessment tools that new curriculum suggests to the teachers include anecdotal classroom records giving information about the student's performance during classes and rubrics that help the teacher to observe and assess if the student has achieve the expected outcomes. Similar to the previous curriculum, the new curriculum also suggests using traditional assessment tools such as multiple choice tests and fill-in-the-blank type questions. However, it is noted that *'these are not the only ways of assessment'* and encourages the teacher to *'observe and assess students' performances during lab work, group works and other classroom activities.*

CONCLUSION AND DISCUSSION

The analysis conducted in the light of predetermined and emerging themes indicated that there is a remarkable difference, which could be seen as a paradigmatic shift, between the approaches and philosophical standpoint of previous and new biology curricula regarding their curriculum emphasis, approach to the nature of scientific knowledge, theories of learning, the models of teaching and the approach to the assessment of learning. The summary of the main findings are presented in Table 1.

The themes that were utilized in comparing the two curricula are placed on the left hand-side column in the table. The approach of the previous biology curriculum regarding these themes is presented on the middle column whereas the approach of the new curriculum is presented on the right hand-side column.

What this summary and detailed analysis presented earlier illustrated is that a dramatic paradigm shift has taken place at secondary level science education in Turkey. The curriculum reform experienced in Turkey has introduced a new world for teachers, which is fundamentally different from the previous one. In this new educational world, teachers face with new educational aims and objectives, new understanding of the nature of scientific knowledge, a different theory on how people learn and related teaching and assessment approaches. Similar large scale reform movements in education take place almost everywhere in the world (Avenstrup, 2007; Kennedy, 1996). Often, such movements fail to meet with their aims due to strong resistance from the practitioners in the field. Majority of the studies investigating this failure and resistance on the teachers' side attributes to factors such as the top-down nature of the reforms, lack of training, leadership, communication, etc. as the reasons.

The results of this study can be interpreted that the overall reason for resistance to change on teachers' side may be the difficulty (if it is not impossibility) for teachers to comprehend the conceptual framework of the reform (or the new paradigm) as this requires denying the previous educational context in which they established themselves in. Considering the fact that the majority of the current biology teachers in Turkey completed their pre-service education in the framework of the previous curriculum and established themselves and their practices using the theories and approaches embedded in it, they, more than probably, will choose to refuse implementing the new education program with its new approaches. Utilizing Kuhn's (1970) perspective, it can be argued that the greatest resistance would come from the more experienced whereas the new teachers may be more open-minded.

What the results and discussion in this study also implies that these reasons put forward by teachers to explain the reasons for their resistance, such as lack of leadership and the top-down nature of the reforms, in majority of the studies in the field may not be the reasons but their "justifications" for resistance. The aim of this discussion and tentative conclusions produced is neither to treat teachers' accounts as delusions nor to underestimate the findings of the established literature in the field. Also, we are aware that such a discussion requires evidence. This study is a part of a research project that aims to assess educational reforms and teacher resistance using the discussed framework. We believe that viewing change as paradigm shift can be a pivotal conceptual and methodological approach for better understanding the implementation process of and teacher resistance to large-scale educational reform (Schmidt & White, 2004).

Table 1.Summary of the comparison of the two curricula

Themes	***Previous Biology Curriculum***	***New Biology curriculum***
Curriculum Emphasis	Correct Explanations Everyday Coping	Structure of Science Science Technology & Decisions Scientific Skills Development
Nature of Scientific Knowledge	Existing truth or reality Science as body of knowledge Science as collection of facts Verification Objective Scientific knowledge as factual and absolute Cumulative progress in science	Explanations about natural phenomena Testable and falsifiable Contextual Subjective All scientific knowledge is tentative Cumulative and Paradigm Shift
Theories of Learning	Behaviourism Memorizing scientific truths Experiments as a process of verification Transfer of Knowledge Teacher-centred	Constructivism Conceptual change Concept maps Construction of knowledge Student-centred
Models for Teaching	Teacher as a expert Provide clear definition Give accurate explanations Present scientific truths	Teacher as a guide Pay attentions students' misconceptions Interacting with students
Assessment	Summative Assessment of products Traditional assessment tools End of unit assessment	Formative Assessing processes and products Alternative assessment tools In process assessment

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HOW USEFUL WAS OUR SCIENCE EDUCATION FOR SCIENCE TEACHERS IN REAL CLASSROOM SITUATIONS?

Atle Ivar Olsen
Nesna University College
ao@hinesna.no

Johannes Tveita
Nesna University College
jt@hinesna.no

Frode Henanger
Nesna University College
fh@hinesna.no

Wenche Sørmo
Nesna University College
ws@hinesna.no

Bjørn S. Pedersen
Nesna University College
bp@hinesna.no

ABSTRACT

Few studies have been done in Norway to evaluate our own education of science teacher students, despite that this could give invaluable information to improve the courses to be more useful for coming science teachers in real teaching situations. To evaluate our science courses, we sent out a questionnaire to former science students. In addition to questions about the relevance of the science education they were given at Nesna University College, we also asked questions about related topics like teachers attitudes to science and experiences in science teaching, what happens in the classroom, equipment and teaching conditions at the schools, text books and the need for professional updating. Major findings were that the students were mostly satisfied with the foundation they had gotten in our science courses and although the chemistry part had the lowest score it was still quite positive. The science teachers revealed a need for continuing education in subjects like chemistry and physics, as well as in Science and Technology, and they also wanted to learn more about equipment and instruments.

Keywords: *teacher students, science, evaluation of science courses, pupil-activity, questionnaire, continuing education*

INTRODUCTION

Nesna University College has from 1978 given becoming teachers (in this paper called students) an opportunity to specialize in how to teach science subjects (physics, chemistry, biology, geology and science didactics) in school, especially for primary school and secondary school. We have no special prerequisites for course entry, and it is the same course for both primary- and secondary school teachers. A main goal with our teaching has been to let students work with active learning methods like hands-on experiences, outdoor education, group work and discussions, all based on the constructivistic view of learning. By focusing on activities, there has been less time for the theoretical aspects of the science in the education. We have focused on teaching students to use concepts and explaining models which can be used in primary and secondary school (Olsen et al., 2008).
We will compare some of the findings from this investigation with results from Norway from TIMMS (Martin et al., 2007) and SISS (Sjøberg, 1986). The relation between the science teacher education and the in-service teaching practice has previously been studied by Andresen and Tveita (1993). The present study is a follow up study to find out more about

how the teachers who have specialized in science at Nesna University College have experienced life as science teachers. We will in this paper give an overview of the main results from the project and with the main focus on the following questions:

How did our former students consider the content and relevance of the science courses that were given at Nesna University College to meet their needs in teaching pupils? What was satisfactory and what should be improved?

METHODS

A questionnaire was worked out and tested on 5 former students that then were interviewed about it to get feedback. After revision, it was sent out to all 224 former students (99 males and 125 females) who had specialized in science in Nesna in the period from 1990 to 2007. Of these, we have received answers from 116 (50 male, 64 female, 2 did not answer about gender; 46 only primary school- and 26 only secondary school teachers), a response rate of 52 percent. We have an ongoing follow up study to find out why 48 % did not answer. The questionnaire was divided into sections with questions about the following parts:

A: Background information
B: Teaching experience
C: Teaching practice and what happens in the classroom and to what extent the teachers wanted changes in their teaching
D: Equipment available for science teaching
E: Attitude and experience with science
F: Need for follow up education
G: Relevance of the science courses at Nesna University College
H: Attitudes to science

Data on Likert scales (mostly from 1 to 5 with a neutral value of 3.0) were transformed to a decimal number (0.00-1.00). SPSS (Version 17.0) has been used to calculate means, and implement t-tests as is commonly done for this kind of data, although data on this form is non-normal distributed. Level of significance is given when appropriate. Means are given with standard deviation.

Factor analysis was used to see if we could identify different types of teachers based on what they reported to happen in their science classroom. We made a rotated component matrix in SPSS (Rotation method: varimax with Kaiser Normalization, excluding cases pair wise). Factor analysis is a technique that analyzes the structure of correlations in data sets consisting of many items to determine whether there are common underlying dimensions/factors (Sannes, 2005).

RESULTS AND DISCUSSION

General feedback on our science courses and teachers need for follow up studies

This paper deals with the answers from most parts of the investigation. More results from part C are presented by Sørmo et al. (2010). Overall, the students seemed to be satisfied with the basis they had after taking our science courses as they gave a score of 0.76 ± 0.18 on a general question about the relevance of what they had learnt. For the biology and physics parts they were also very satisfied (Scores of 0.70 ± 0.20 and 0.68 ± 0.19) whereas for chemistry the score was somewhat lower (0.58 ± 0.20), although still above the neutral value. High scores were also obtained for the methodical and didactic parts of the science courses (0.68 ± 0.21), field work (0.75 ± 0.19) and for experiments (0.76 ± 0.22).

There is of course a connection between what they need follow up studies in and what they were least satisfied with in the science classes, as is easy too see for chemistry (0.64, Table 1). The need for continuing education among our teachers varies between 0.37 and 0.72 (Table 1). The highest scoring topic is “becoming more familiar with apparatus and equipment”. Second and third is “technology and design” (0.67) and “budding researcher (young researcher)” (0.65). This makes it clear that the teachers feel they need more education in many of the new elements in the new curriculum (LK-06), such as “Budding researcher” and technology and design.

Table 1. Teachers need for continuing education. The scale runs from 0 (no need) to 1 (highest need), and there is no neutral for this scale. N = 90.

The need for continuing education	All	Primary	Secondary
Become more familiar with apparatus and equipment	0.72	0.70	0.73
Technology and design	0.67	0.65	0.74
Methodology in relation to the implementation of the “Budding researcher” and the new curriculum (LK-06)	0.65	0.64	0.71
(academic) Update in chemistry	0.64	0.59	0.68
(academic) Update in physics	0.63	0.56	0.71
Presentation and testing of ready-made teaching plans and science experiments	0.63	0.62	0.66
Excursion methods and ideas	0.62	0.59	0.66
Project methodology and ideas	0.61	0.64	0.56
Use of models in science teaching	0.60	0.60	0.58
How to evaluate in school science	0.58	0.56	0.58
Learn about pupils' alternative conceptions and how to identify them	0.56	0.58	0.51
Science teaching and pupils' daily live	0.52	0.51	0.53
How to find pupils' prior knowledge	0.51	0.54	0.45
Science education and social issues	0.51	0.49	0.52
Coordination of the natural sciences with other subjects	0.49	0.53	0.44
Computer as an aid in science teaching	0.49	0.53	0.44
Cooperation of science subjects	0.48	0.52	0.41
(academic) Update i biology	0.41	0.41	0.39
Review and critique of curricula and learning material	0.39	0.40	0.39
Topics from the history and philosophy of science	0.35	0.37	0.29
Average	**0.55**	**0.55**	**0.55**

It seems that the teachers are in need of academic update in both chemistry and physics, but less so in biology. This harmonises with findings in TIMMS (Martin et al., 2007) that indicate that Norwegian teachers feel more insecure in chemistry and physics topics compared to biology.

The average score for primary- and secondary school teachers for need for all kind of continuing education is the same (0.55). However, primary school teachers do not emphasize academic update as much as teachers in secondary school, but emphasize either projects, collaboration with other disciplines, presentation and testing of ready-made arrangements. Secondary school teachers, on the other side, have more need for continuing education in chemistry and physics.

When it comes to gender differences, females report a slightly higher need for continuing education than males (Table 2). When all differences less than 0.05 are omitted, all gender differences are in favour of the females (Table 2). This is in contrast to what extend they actually are participating in this kind of education, where the females score is 0.64 while the males score is 0.72 (these figures are not reported in the tables). This is a striking contrast, because the females say they are in need of more continuing education compared with the males, but they participate less in this kind of education than the males. Possible explanations could be that the males feel more secure because of their participation in continuing education. It might also be explained by gender roles, as maybe women do not want to travel away from the family to get continuing education in the same extent as men? However, follow up studies are necessary to find explanations for this.

The greatest gender difference was the need to become more familiar with apparatus and equipment, where the difference is 0.19 (statistically significant, $p < 0.01$). This is, however, not surprising because we often observe that the males dominate in the classroom during experiments and thus become more accustomed in using equipment.

Table 2. Gender differences in need of continuing education. Only differences more than 0.05 are shown.

The need for continuing education	**Female N = 52**	**Male N = 38**	**Female-Male**
Become more familiar with apparatus and equipment	0.80	0.61	0.19
Science Teaching and pupils' daily life	0.56	0.45	0.11
(academic) Update in physics	0.68	0.58	0.10
Cooperation of science subjects	0.57	0.47	0.10
How to find pupils' prior knowledge	0.56	0.47	0.09
Presentation and testing of ready-made teaching plans and science experiments	0.64	0.56	0.08
Project methodology and ideas	0.64	0.56	0.08
How to evaluate in school science	0.61	0.54	0.07
Learn about pupils' alternative conceptions and how to identify them	0.60	0.53	0.07
Technology and design	0.69	0.63	0.06
Average of all statements	**0.58**	**0.53**	**0.05**

Table 3 shows that the teachers report the most common aids in science classes to be projector, computers and internet. It seems clear that the infrastructure in the classroom is good, but the equipment for science activities is more lacking. It is also clear that equipment for teaching astronomy and geosciences are in short demand. Many of the teachers report that they do not have a classroom especially equipped for science teaching as 41 % are lacking science classroom all together.

Table 3: Aids in science teaching. The scale runs from 0 (no equipment) until 1 (perfectly equipped). The last column is the sum of the two first columns. N = 90.

Aids in science teaching	**Lacking equipment**	**Poorly equipped**	**Intermediate equipped**	**Well equipped**	**Poorly or less**
Astronomy	0.23	0.60	0.14	0.03	**0.83**
Geosciences	0.16	0.54	0.24	0.06	**0.70**
“Smartboard”	0.56	0.10	0.13	0.21	**0.66**
Activities in physics	0.06	0.53	0.29	0.12	**0.59**
Science classroom	0.41	0.16	0.27	0.16	**0.57**
Video, film and pictures	0.09	0.47	0.32	0.12	**0.56**
Activities in chemistry	0.07	0.47	0.32	0.14	**0.54**
Equipment for outdoor education in science	0.01	0.47	0.36	0.16	**0.48**
Animals and plants	0.03	0.42	0.42	0.13	**0.45**
Body and health	0.03	0.33	0.52	0.12	**0.36**
Manuals and encyclopaedias	0.01	0.29	0.54	0.16	**0.30**
Computers/internet	0.03	0.16	0.35	0.46	**0.19**
(Video-) Projector	0.07	0.08	0.29	0.56	**0.15**
Average	**0.14**	**0.35**	**0.32**	**0.18**	**0.49**

When asked if access to a science classroom limits the possibilities for good science teaching, the teachers in primary school agree more to this statement (score 0.61) than the teachers in secondary school (score 0.41). Norwegian primary schools are mostly lacking science classrooms, but the results clearly show that this affects the science classes. Also, we find a gender difference for this statement (female 0.61 vs. males 0.48), but this is probably mainly because there are most females working as teachers in primary schools.

Teachers' goal for science classes

We have asked the science teachers about which goals they consider most important for their classes. Most of the goals are the same as in Andresen and Tveita (1993) and Sjøberg (1986) so that we can compare and see if there have been any changes over about 20 years. Table 4 shows the figures from these studies arranged in sequence of what the teachers in our study consider the most important goals for their science classes.

Table 4. Ideally most important goals for science teachers for classes in science. Scale from 0.00 to 1.00 where 0.50 is a neutral value. Also given are data from Andresen and Tveita (1993) and SISS (Sjøberg, 1986). Last column is the difference between the scores in the present study and Andresen and Tveita (A & T) (1993). N = 102.

	Goal	Present study	A. & T.	SISS	Diff. to A. & T.
1	To stimulate interest and curiosity	0.95	0.94	-	0.01
2	To develop respect for and solidarity with nature	0.92	0.96	0.87	-0.04
3	To develop attitudes for a sound use of natural resources	0.91	0.97	0.87	-0.06
4	To develop a questioning attitude	0.91	0.88	-	0.02
5	To take care of own and others health	0.89	0.91	0.78	-0.02
6	To develop independence and respect	0.87	0.80	0.73	0.06
7	To develop a critical sense for the possibilities and limitations of science	0.86	0.68	0.74	0.18
8	To impart science as intellectually exciting and stimulating	0.83	0.67	0.64	0.16
9	To develop an understanding for the importance of science	0.83	-	-	-
10	To maintain and develop girls interest for science	0.81	0.73	0.70	0.08
11	To impart science as part of our culture	0.80	0.56	0.63	0.24
12	To prepare for daily life	0.79	0.84	0.77	-0.05
13	To understand important concepts, laws and theories	0.78	0.63	0.73	0.15
14	To develop systematic problem-solving techniques	0.78	-		-
15	To prepare for decisions in society	0.77	0.76	0.68	0.02
16	To develop scientific method of work	0.76	0.68	0.64	0.08
17	To prepare for education and work	0.76	0.61	0.73	0.15
18	To supply society with technologically highly skilled workers	0.73	0.53	0.54	0.20
19	To develop skills and techniques in use of instruments and equipment.	0.63	0.51	0.59	0.11
20	To prepare for tests and exams	0.55	0.25	0.45	0.30
	Average	0.81	0.72	0.69	0.09

The scores from the present study is on average 0.09 higher than what Andresen and Tveita (1993) obtained, and this may show that the science teachers consider many goals as more important for science in school today. The largest change between the two studies (differences in scores) is for the goal "To prepare for tests and exams", with more than a double value in this study, even though this still is ranked as the least important one (as also in SISS (Sjøberg, 1986)). We believe that this is a reflexion of the debate in Norway about national tests of pupils the last years. Also, the results and debates after the latest TIMMS and PISA investigations have led to more focus on the importance of testing and results from test of pupils in science.

Also scoring much higher in the present study are the goals "To impart science as part of our culture" and "To supply society with technologically highly skilled workers". This may also be a result of today's political discussions in Norway, and the importance of technology is especially stressed in the new Norwegian curriculum (LK-06).

Whereas the scores are higher in the present study, a few goals have lower scores, compared to the 1993 study (Andresen and Tveita). The goal "To prepare for daily life" scores 0.79 in the present study, opposed to 0.84 in Andresen and Tveita (1993), and is now closer to the value of 0.77 from SISS (Sjøberg, 1986). Also, the scores for "To develop respect for and solidarity with nature" and "To develop attitudes for a sound use of natural resources" are lower in the present study. However, the scores are still among the highest, and the reduction is most likely because these already had very high values in Andresen and Tveita (1993) (Table 4). This is also reflected if we rank the goals, in that these two goals are ranked among top 3 in both investigations. Other differences in ranking are that "To impart science as part of our culture" is ranked much higher now (11 vs. 15) and that "To prepare for daily life" and "To prepare for decisions in society" have dropped down on the list (from place 6 to 11 and from place 8 to 13, respectively, excluding questions from the present study which were not included in the two previous studies).

The scores from SISS (Sjøberg, 1986) are on average 0.12 lower than in the present study and comparable to Andresen and Tveita (1993), although SISS included all teachers in primary school and science teacher in secondary school (average of both is used here). The ranking of the goals is quite similar, maybe except that "To impart science as part of our culture" also scores low in SISS compared to the present study (ranked as number 13 vs. 8, out of the 16 goals).

We found only small differences between primary- and secondary school teachers about what goals they consider most important for their classes (data not shown as they are very similar to data given in Table 4). This may to some extent be because they all have a similar education in science from Nesna without any specializing for either primary- or secondary school.

Gender differences in goals

It was striking to find that there were very slight differences between the sexes about what were the most important goals for their science classes. Out of the 20 goals, 14 had less than 0.05 in difference and for the remaining, 5 had exactly 0.05 in difference (Table 5). Goals with some differences are shown in Table 5 (the rest of the values with gender differences less than 0.05 can be found in Table 4).

Table 5. Gender differences between the most important goals for science classes. Only goals where difference between sexes was 0.05 or more is shown.

Goals	Both	Male N= 43	Female N = 57	M – F
To develop independence and respect	0.87	0.84	0.89	-0.05
To impart science as part of our culture	0.79	0.76	0.82	-0.05
To prepare for decisions in society	0.78	0.75	0.80	-0.05
To develop systematic problem-solving techniques	0.78	0.81	0.76	0.05
To prepare for education and work	0.75	0.78	0.73	0.05
To supply society with technologically highly skilled workers	0.73	0.79	0.69	0.10
Average of all 20 goals	0.80	0.81	0.80	

It is remarkable that the average score was almost identical and that we found some gender difference for only one of the 20 goals, for the goal "To supply society with technologically highly skilled workers" where the score for boys was higher (P = 0.047, *t*-test). Science and technology (STS) is more stressed in the new Norwegian curriculum (LK-06) than it has been before, and it is possible that girls feel more uncertain in especially technology.

Identity as science teachers

We have in an earlier publication from this project shown that teachers from Nesna like to teach science and have an identity as science teachers (Olsen et al., 2008).

Table 6. Factor analyses: Rotated Component Matrix. Rotation Method: Varimax with Kaiser Normalization. Extraction: Numbers of factors: (5). Options: exclude cases pair wise, suppress absolute values less than (0.3), sorted by size. N = 90

Rotated Component Matrix	1	2	3	4	5
Performs experiments or investigations	0.797				
pupils do experiments	0.783				
Let the pupils conduct experiments or investigations	0.783				
Designing or planning experiment of investigations	0.754				
Work in group with experiments or investigations	0.683				
The teacher shows an experiment	0.655				
Reports from experiments	0.552				
Using scientific work methods	0.530				
Pupils work in groups	0.530				
Formulate hypothesis or predictions that could be tested	0.512				
Pupils are divided into girl groups and boy groups	0.428				
Allows pupils to formulate hypothesis or predictions that could be tested	0.357				
The teacher gives a homework assignment		0.583			
Teaches about the nature of science and scientific methods of work		0.530			
Allows the pupils to write down the explanation for what was observed and why it happened		0.528			
Pupils have written test		0.503			
Allows pupils to explain what was observed and why it happened		0.490			
The teacher use time to silence the class		0.472			
Interdisciplinary theme work		-0.427			
The teacher hears the pupils in homework		0.427			
Let the pupils present their work for the class		0.410			
The teacher is going through new material		0.387			
We are discussing something (science) which has been in the newspaper or we have seen on TV		0.365			
Pupils working on the internet			0.766		
Pupils are using PCs			0.751		
The pupils participating in the planning of teaching			0.549		
TV, video, films, slides			0.487		
Pupils listen to the teacher the majority of the lessons			-0.457		
To find information, we use other sources than the textbook			0.379		
Project work			0.370		
The teacher examines the pupils everyday notions				0.714	
The teacher examines the pupils knowledge prior to each theme				0.693	
Field work and excursions				0.573	
Outdoor education				0.533	
Trying to link what they learn in science to everyday life				0.527	
Discussion / conversation classes				0.475	
Allows the pupils to design or plan the experiments or investigations				0.460	
Role play / drama				0.391	
The pupils read the textbook					0.636
Pupils do written exercises					0.605
Pupils have an oral test					0.405
The teacher writes on the chalkboard					0.389
	1	**2**	**3**	**4**	**5**

In Norwegian schools, many teachers who teach science are not specialized in science and have to teach other subjects as well, even subjects they have not had any deepening in their education. As a result, there will be differences in the way they identify themselves as science teachers. We have analyzed (factor analysis) the data to see if we can identify different types of teachers, and the analysis showed that the science teachers could be grouped into 5 different types of teachers, see Table 6. The 5 different types (one in each column, Table 6) of teachers we have identified can be described as follow:

The first type of teacher (Column 1, Table 6) seems to be a teacher using scientific methods of work, and therefore use these methods as the most important part of her/his classes. The pupils do many experiments and investigations, and they want the pupils to learn how to formulate and test hypothesis, and to observe and write report from the experiment.

The second type of teacher (Column 2, Table 6) seems to be a teacher that is concerned about if the pupils understand the science that has been taught. The teacher goes through new material, teaches about the nature of science and scientific methods of work, and allows the pupils to explain and write down the explanation, and why it happened. They are discussing science that has been in media, and give the pupils homework and hear them in homework as well.

The third type of teacher (Column 3, Table 6) seems to be a teacher that prefers to use projects in their classes. He/she wants the pupils to find information themselves rather than listen to the teacher most of the time. The pupils use other sources than the textbook to find information, such as PCs, the internet and media (newspapers and TV). The teacher also allows the pupils to take part of the planning of the lessons.

The fourth type of teacher (Column 4, Table 6) seems to be a teacher that is more pupil-focused. The base for teaching is the pupils' prior knowledge and everyday notions. This teacher tries to link what they learn in science to everyday life, and use activity based learning such as discussions, role play, drama and field work and excursions.

The fifth type of teacher (Column 5, Table 6) seems to be the traditional teacher that writes on the chalkboard, and let the pupils read the textbook before they do written exercises. To check that the pupils have gotten an understanding, they test them orally.

It was interesting to see that 5 recognizable types of teachers could be identified, even if it is not correct to assume that all science teachers can be placed into (only) one of the types. But the fact that the type 5, the more traditional teacher, can be identified among the teachers shows that we still have room for improvement as we want the science teachers educated at Nesna University College to be pupil oriented and use varied teaching-methods like many hands-on activities etc. However, many other factors will of course influence the teachers as they are a very inhomogeneous group with different attitudes and previous experiences.

These results will be used to make constructs for further analysis to find about more about the different types of teachers that we have identified, but the results are interesting and will also be use directly in our science education courses.

CONCLUSION

This survey has given us valuable input about parts of our science courses that need improvements and refinements, and it is also clear that we will have to put even more emphasis on the physics and chemistry part in our science courses. We do have student evaluations in every class, but it is just as important to get feedback from the teachers (former science students) after they have been teaching science in school and then have more experience and a better understanding of the needs they have in real teaching situations. However, we have also received feedback on what parts of our science courses that students are satisfied with and that we should not change. We have also many interesting results that we will use directly in our science education courses (E. g. about teachers types). Another benefit from the project is that it has initiated several follow up studies, see Ellingsen et al. (2010) and Tveita and Henanger (2010), and we have identified more subjects that we would like to follow up in separate studies.

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THE ROLE OF NCCP TIME FOR ENHANCING CHILDREN'S CREATIVITY IN TECHNOLOGY

Beverley Jane
Monash University
beverley.jane@education.monash.edu.au

Coral Campbell
Deakin University
coral.campbell@deakin.edu.au

ABSTRACT

The focus of our research project was the question Can children's creativity be enhanced by including a period of non-conscious cognitive process (NCCP) time? During this non-thinking time the brain makes connections between independent ideas, forgets inappropriate responses, and makes available more relevant responses for problem solving. The research generated cases of several primary school classrooms as the teachers incorporated NCCP time in their design technology sessions. Children were observed and teachers interviewed about their perceptions of children's creativity as the children designed and produced recycling devices. The cases revealed an optimum time frame of several days for non-conscious cognitive processing. These findings have implications for teachers of technology who assign the same day and time each week for technology learning. During the non-task time, which included the NCCP time, children were able to discuss their ideas with family members. As children learn in socio-cultural contexts, these discussions can be fruitful. The teachers indicated that peer discussions also played an important role after the generation of designs.

Keywords: *Children's creativity, design technology, non-conscious cognitive processing (NCCP) time.*

INTRODUCTION: CREATIVITY IN TECHNOLOGY EDUCATION

Creative problem-solving is an integral component of technology education in schools (Barak & Goffer, 2002). Peterson (2001) contends that "Creativity is closely associated with advances in technology, and it is logical that an important aspect of technology education is the development of creative abilities". He recognizes that creativity in technology education relates to students being actively engaged in generating novel products as solutions to technological problems. The broad range of topics and the versatility of approaches that can be included within the technology classroom provide a range of opportunities for the technology teacher to implement programs aimed to foster higher order thinking skills – in particular both analytical and creative thinking. A structure that employs a careful balance between content knowledge and process (Jones, 1997) but also successfully incorporates higher order thinking should be implemented within the technology classroom (Middleton, 2005).

In the technology process, it is through the imposition of the unsolved problem that stimulates the thinking student to discover a viable solution to satisfy a human and/or environmental need. This aspect of the technology process suggests that the learner seeks innovation in a practical context. Creative and analytical thinking support cognitive processing in the context of student problem-solving and therefore are compliant in sustaining the development of the technological knowledge, skills and values, according to Howard-Jones (2002) who proposed a model of creative cognition for supporting strategies that foster creativity in the classroom. Howard-Jones also suggested that when thinking creatively, children generate new ideas through remote associations and brainstorming and this type of thinking is enhanced when attention is allowed to wander in a relaxed and uncompetitive environment. Other researchers (such as Forgays & Forgays, 1992) have also indicated that being involved in unrelated activities have promoted solutions to problems and increased children's creativity. Larger numbers of initial ideas also increased the likelihood of children developing a more original final solution (such as using brainstorming sessions). To allow the generative state to occur, Howard-Jones (2002) suggested the use of a period of time in which student attention is not focused on the technology task. This time allows the individual to be able to sub-consciously combine concepts and produce novel combinations of remotely-associated ideas. It was this idea of a non-conscious cognitive process (NCCP) time that was tested in a study by Webster, Campbell and Jane (2005) in an intervention program undertaken in primary technology classes. Reflection on that research has enabled us to theorize how design technology education with a built in NCCP time can contribute to children's creative thinking.

AIMS OF THE RESEARCH

The overall purpose of the research was to investigate the notion that children's creativity can be enhanced through the inclusion of a non-conscious cognitive processing (NCCP) time in the technology process. The purpose of the research was two-fold. Firstly, we aimed to explore the structures, relationships and content of the technological experiences at several school settings. This exploration entailed engagement of the interpretive categories of the social, educational and professional values, beliefs and attitudes of the main participants. Secondly, we aimed to study how the children's creativity was enhanced through the introduction of an intervention strategy – that of NCCP time.

RESEARCH DESIGN

In our preliminary discussions we decided that a case study approach would be most appropriate as our basic intention was to seek to describe and develop an understanding of the setting and the children's creativity, rather than for the research to be an active agent in evaluating outcomes or instigating change. However, an intervention process was also required, as in discussion with our teacher participants, we realised that what we were suggesting, was something new and different to their normal classroom practice.

Accordingly we developed case studies of each of three sites – primary schools in the state of Victoria, Australia, by gathering data to describe the experiences of the children and teachers, and to illuminate the approaches to learning and the developing creativity. Both the perspectives of teachers and children were sought. Since this interpretive study was 'bounded' in both time and space, we identified the case study as the most appropriate research approach due to its capacity to accommodate the complexity of the situation as it actively engages the changing dynamics of the setting and its social aspects (Campbell 2000 p. 80). Additionally we recognized the validity and compatibility in this study of Stake's assertion (Bryman 2001, p. 55) that 'The utility of case research to practitioners and policy makers is in its extension of experience'; and that case studies centre on '…research on a single case with a view to revealing important features about its nature'.

Each setting or site we investigated was a 'bounded system' in several ways. From the physical perspective, the system is located as a dedicated area and described by the specificity of the technology task within the classroom environment. One school was in an urban area, one in a rural area and the third in a regional centre. Each site is also bounded in that we collected information over a specific period - a snatch in time. The research approach needed to be sensitive to the constraints and opportunities that presented within the research study. Reflection on the data enabled us to provide an interpretation of the learning related to enhanced creativity exhibited by the children as evidenced by the technological products they produced within the context of each site.

Participants were primary school children and their teachers, situated in three schools across the state of Victoria, in metropolitan Melbourne, regional Geelong and rural Mornington Peninsula. Two teachers (at year three or four level) from each school agreed to participate in the study and their role was to teach a technology unit across at least four lessons. Surprisingly to us, most of these teachers had no practical experience teaching technology, although they had taught science. Accordingly, professional learning sessions were conducted with the teachers to ensure that they were aware of what classroom technology was in practice. These sessions led to a change in their approach, with most teachers incorporating some form of brainstorming at the start of the process. Another change in practice was allowing the children time during the planning and construction time to 'think through' their ideas and problem-solve with others. Problem-solving thinking is an important aspect that can lead to enhanced creative thinking. The study was conducted in an authentic setting – the normal classroom in which children's learning occurred. The children worked in pairs or small groups to address the following open-ended design brief.

> Design and make a model of a small recycling device for the home or garden. Your product should be made mainly from recycled materials.

The teachers were requested to incorporate NCCP time between session one - when the design brief was introduced and the brainstorming (or familiarisation process) was undertaken - and session two. In practice the NCCP time varied from school to school, depending on the classroom timetable and time constraints. The length of NCCP time was: School A~ 5 days, School B ~3 days, and School C~ 7 days for one class, 14 days for another class. In this way the teachers gave children thinking time or extended periods where discussions between them were encouraged. Teachers also allowed modifications after the evaluation time. Children were encouraged to document their ideas in a journal - *My Thinking and Ideas Book,* as a means of recording previous ideas and being able to return to them should they wish. The journal belonged to the child and was not assessed by the teacher as part of the process. This approach gave the journal some legitimacy in the children's minds as a personal tool rather than a teacher requirement.

As it was not our intention as researchers to take an artefact focus, we studied the generation of new or different solutions as a function of creative thinking, by taking account of the children's initial suggestions for their recycling devices, both written and drawn. Evidence of the children's involvement in the technological process was obtained through their documentation of their drawings, ideas, sources of ideas and reflections in their journal - *My Thinking and Ideas Book.* We spent time in the classrooms observing the children as they engaged in the technological process, and listened as the children shared their technological knowledge during presentations to their peers. Informal conversations occurred naturally with the children as they eagerly shared with us how they made their recycling devices. Photographs of children's designs were taken, both from the point of view of illustrating any novel or creative idea but also as a validation to the children of the value of the task. Once the technological unit was completed, we carried out informal interviews with the teachers who revealed their perspectives of the influence of NCCP time on children's creativity.

RESEARCH RESULTS

In responding to the Design Brief, most children indicated that they read books and spoke with their parents, teachers and each other, in an attempt to think of something that was new, or at least different, to what was currently available on the commercial market. Many took examples of familiar items and attempted to modify them so that they were more efficient or ‘better’. Some tried to think of an entirely new way of approaching the problem or issue. As part of their routine classroom studies, the children had a strong understanding of the background information about recycling and environmental health. For most of them, the topic was sufficiently familiar that they did not need to have additional information. However, the teachers did spend some time brainstorming both the idea of recycling and discussing aspects of the design task required of the children. The following comments are representative of the teachers interviewed.

- Children were frustrated with that [NCCP time] because they wanted to get started.
- In hindsight, a week for incubation [NCCP time] was too long.
- Once they had set up what they wanted to do…very, very rarely did they change that idea. The kids that changed mostly were the more practical kids.
- Unexpectedly several children who had not been observed showing creativity prior to the task, had generated very unusual designs.
- There were ‘quite a few’ children who needed to change their designs to accommodate functionality.
- Additionally, children had to modify their designs based on limited resources or limited personal manipulative skills. This they found particularly frustrating – having an idea but not being able to produce from it.
- There were not many new concepts that the children could generate, but there was a diversity of ideas within a particular topic.
- The children needed to have an adequate understanding of the topic. Children who possessed a broader knowledge of recycling appeared to produce devices that were different.
- Allowing children to take their ideas home was particularly helpful as this gave them time to discuss ideas with family members.
- Some children showed original, creative thinking, while others ‘shared’ ideas with their peers and then made modifications.

The children’s creativity was demonstrated in various ways. How the children approached developing the design of the product indicated an engagement with the creative ideas. The novelty aspect was evident in some of the children’s designs. One Year four teacher commented; “some children came up with their own, original ideas (e.g. theme park for worms!). Some designs involved a variety of processes (e.g. crushing, rolling etc.) that were creative”. The designer of the worm farm wrote in her journal.

My worm farm recycles food scraps. It has a playground and a sorting belt that sorts out scraps. I was thinking how to construct my model and what to use. The worms break down the vegetables and turn it into compost. My worm farm looks good because it’s different to everyone else’s project. It is different to what I’ve seen because it involves my own ideas. If I had different materials I would make an improved version. I think my project is a great success and I’m proud of myself (Year four girl).

Throughout the construction of their devices, the children were actively involved in a problem-solving process – often having to devise new solutions. Some children created novel ideas, but were hampered by the limitations of resourcing and even expectations of their age group. One child had a very creative idea to clean a cat litter tray using a magnetic force. Unfortunately, practicalities forced her to abandon her original creative idea and to move to something that was ‘do-able’. Another child, at a different site, wrote in his journal that he was so frustrated by not being able to complete his fire-log maker machine as he wasn’t allowed to use electricity and didn’t know how to do that part anyway. In the end, he created a box with specific instruction on the outside, but no content, because he could not include any machinery.

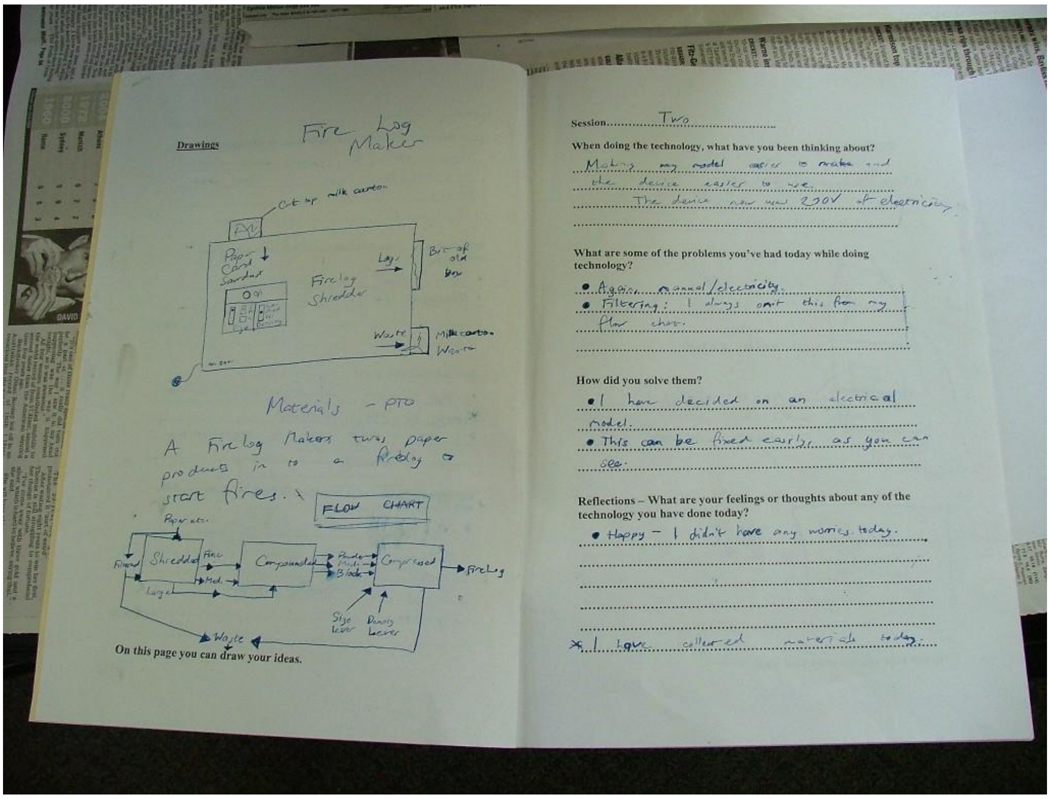

Figure 1 – My Thinking and Ideas Book - entry for the Fire- log maker

DISCUSSION: SOCIAL CREATIVITY AND NCCP TIME

In that intervention program, at all three sites, teachers took time to introduce the task, to brainstorm or to undertake familiarization activities prior to the children commencing the project. Time was spent clarifying with the children what the design brief and the specifications meant. Teachers were aware to leave the task as open-ended as possible so that they would not impose further restrictions or specifications outside the design brief itself. This allowed children to interpret the task in their own mind and by their own set of understandings and experiences. We observed that children already had strong content knowledge of environmental education – refuse, reduce, reuse and recycle was a theme that had already been introduced to the children previously.

During the interviews the teachers commented that allowing the children to discuss their ideas with family members was beneficial. This valuing of community orientation to learning, rather than viewing learning from an individual's perspective, is consistent with Gordon's phenomenological study of eight families involved in *Starwatcher* activities. Gordon (2006, cited in Fleer & March, 2009) found that engagement in learning was enhanced through experiential learning when children and adults participated in hands on activities associated with astronomy. Our study identified that the provision of time between sessions allowed children to discuss their ideas amongst their peers and family members, thus deepening their content knowledge (as a prerequisite for creative thinking) and allowed NCCP time to be activated. In so doing, shared expertise and social creativity came into play. In her study on expertise and creativity, Reilly (2008) expanded the notion of expertise by not restricting it to being situated in an individual. Rather it "can emerge from a system of shared experience" (p. 59). Our study revealed that the path from the initial introduction of the design brief to ideation involved two or more people over an extended period of time. The NCCP time was occurring outside these social interactions, but providing further 'new ideas' to be discussed with others. Thus the shared time can facilitate social or collective creativity. Barrett (1999, cited in Reilly, 2008) points out that “Social creativity has come to mean the functional and dialogic relationships between persons concerning a task embedded in a specific environment, which is nested in a socio-historical frame” (p. 64). In our study, when the children worked together in pairs or small groups on the technological task, language became a tool of creativity. Therefore dialogical interaction in the context of technological activity can foster creativity. Solutions to problems can emerge through conversations between group members. So the ‘copied’ ideas that are then modified can be viewed as part of a social creativity process. Even for those children who tended to work alone and appeared to generate their own novel ideas, the social context would have provided additional stimulus for creativity.

CONCLUSION

In undertaking this research, our initial aim was to ‘enhance children’s creativity through the inclusion of a non-conscious cognitive processing time (NCCP) in the technology process.’ This was a distinct intervention. We acknowledge that other factors such as brainstorming, task criteria, children’s knowledge, learning dispositions and higher order thinking practice all aid a child in the development of their creative thinking. These other factors became apparent at the time of talking with the children and teachers about the entire process. While we can definitively state that the inclusion of NCCP time enhanced creativity, the other factors were present as part of normal classroom practice. This is a very positive outcome of the research – that many of the pre-conditions necessary to enhance creativity are already present in some classrooms.

The use of the non-conscious cognitive processing (NCCP) time cannot be ‘taught’. Rather it is activated at the individual level through free-flow mental states. Remote mental connections can be made non-consciously which produce unusual and original ideas. The implication of our study for teachers is that when NCCP time is allowed for in curriculum planning, and incorporated as part of the technological process, novel ideas and creativity are enhanced. With the provision of NCCP time comes a period of non-task time when children are given opportunities to informally share their fledgling ideas in a social context. Teaching design technology in this way can contribute significantly to enhancing children’s creativity.

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SECONDARY STUDENTS' INTEREST IN SCIENCE AND TECHNOLOGY UNDERSTOOD AS A MEDIA EFFECT

Anders Jidesjö

Linköping University in Sweden

anders.jidesjo@liu.se

ABSTRACT

Young people's interest in science and technology and their attitudes towards those knowledge fields has been an object for research for a long time. Current research points to cultural aspects and informal learning as important to understand these questions. In this study I use content analysis to compare what secondary students want to learn about in science and technology with what international popular science television program broadcast and present important similarities. I discuss the results from media theory as modernity having an effect on young people's experiences and that this can be important in understanding the way they encounter school science.

Keywords: *Students' interest, Science, Media*

INTRODUCTION

In a modernized world, science and technology play important parts in culture and affects everyone. This is the starting point by Durant, Evans & Thomas (1989) when investigating the public understanding of science. Furthermore, decision making in society today involve science and should therefore, in compliance with democratic processes, be debated. Also, science itself rests and relies upon public support which is based on public knowledge. This is why we should care. But in a world of many learning opportunities, what stands out as relevant and by whom?

There is a substantial volume of research concerned with secondary students' interest of science and technology. The majority of those studies pay attention to school science. Fewer have presented a picture related to informal settings. In a recent review of students voice in science education, Jenkins (2006) point out that when it comes to what is perceived as being relevant content to learn in school, it is mostly adults perspectives that have had the monopoly. A lot of students in many countries have trouble with apprehending this content as relevant for their lives and personal needs. In addition, there are important similarities between countries in the way young people experience school science (Lyons, 2006). These are some of the reasons why studies into students' perspectives on school science in different countries are important.

The relevance of science education study (ROSE) is the largest research project investigating the students' voice on those issues. One of the results reported from ROSE is that secondary students have interest in science and technology. Their interest is oriented towards specific content, and not towards broad categories like subject areas (Jidesjö et al., 2009) and can be understood as an effect of societal development that have an effect on youth culture (Schreiner, 2006). Schreiner showed this to be the case for many developed countries which imply that there are cultural factors behind questions concerned with students' interest in science and technology. There are more studies pointing in this direction. Baram-Tsabari and Yarden (2005) investigated young people's spontaneous interest in science and technology by analyzing their questions sent to an ‘ask a scientist’ television show in Israel, followed up by a study analyzing children’s questions sent to an ‘ask a scientist’ web site, from several English speaking countries (Baram-Tsabari, Sethi, Bry & Yarden, 2006). In both studies they discuss young people’s interests for science as being strongly influenced by societal development which among other things mean that today you can learn about science in many ways outside school. Young people use media because it is fun and they have grown up with it and there are commercial interests behind as well. By such processes, the way science is treated in educational systems is challenged (Brady & Kumar, 2000; Weigold & Treise, 2004). As several studies are pointing to societal development and the way those circumstances change young people’s out-of-school experiences and thereby what is perceived as relevant to learn, informal science learning is important to investigate in relation to school science learning (Braund & Reiss, 2006).

Science meets public in the media which is the new social contract (Gibbons, 1999). The stories are contextualized by journalists who try to make them intelligible, often in ways that appeal to people's sense of feeling, to entertain and frame but also manipulating. In the case of cloning, which is one example, science is portrayed from science fiction, described in dichotomies and contributes to cultural fears instead of enlightening the public (Huxford, 2000). The way science meet the public on TV in a modern society, is a consequence of political and economical realities but with a keenly alive to customers wants (Cottle, 2004). There are several factors involved in the process from production to reception and the content is affected even before it reaches the press room (Holliman, 2004). Journalists know what attract their users and present their stories with elements that people need to make them purposeful. This of course, has consequences for science citizenship. It is not one single institution that will contribute to a vision of a scientifically literate population (Dhingra, 2006). Media is not only about entertainment. It should be understood as a contributor to young people’s views on science (Ormerod, Rutherford & Wood, 1989). This is not to say that educational settings should try to emulate media. There are evidence of stereotypical sex roles and narrow portrayals of scientists and scientific work (King, 2000). It is more a question of understanding what the development of communication media mean for the experience of science and consequently, what that implies for authentic learning environments (Roth, 1997). Media science and science education can benefit from each other (Salleh, 2001), remembering that the governing body on teacher work are quite differently from ways science knowledge is restricted in other areas (Treagust & Harrison, 2000).

METHODOLOGY AND PURPOSE OF THE STUDY

The purpose of this study descent from two observations. Firstly, several studies concerned with students’ interest for science point out that they have interest for certain contents. Young people seem to be oriented towards a specific substance within those knowledge areas. How can this circumstance be understood? Secondly, many researchers concerned with societal development, culture and modernity related to science education, discuss the need for studies giving an account of media and young people’s experiences due to their development. In a modernized society, is there a possibility that young people’s engagement with science and technology can be understood as a media effect?

The analysis method I have used is founded on results from the ROSE study in Sweden. This empirical data set is part of the international ROSE data reported by Schreiner (2006). Schreiner and Sjøberg (2004) give an account for all details concerning data collection, methodological issues, rationale and underlying ideas in this world wide research project.

The national Swedish data I use have been generated by using the ROSE questionnaire, where 751 students in 2003 in the end of compulsory school have answered 108 questions about ‘what they would like to learn about’ on a four graded Likert scale. The category contained questions concerning astrophysics, earth science, human biology with sex and reproduction, genetics, zoology, botany, chemistry, optics, acoustics, electricity, energy, technology, ‘Science, Technology and Society’ (STS) and ‘Nature of Science’ (NOS). The questions were put in different contexts such as spectacular phenomena, fear, technological ideas and inventions, aesthetical aspects, beauty, care, health, personal use and everyday relevance. The specific topics young people rank as relevant to learn I call a ‘content orientation’ and are much the same for students in the whole modernized part of the world (Schreiner, 2006).

Almost all topics that are part of their content orientation play important parts in science and technology but do not follow the way the traditional school subjects treat the content (Jidesjö et al., 2009). They are like two different content orientations. Young people seem to give precedence to other kind of priorities than the traditional school subjects’ lay stress on. In trying to understand this split, I search for the content orientation that is put forward by the students among other stakeholders that manage science and technology. In this study I have used the method ‘content analysis’ to explore the content that is in charge of one international popular science television channel, i.e. ‘Discovery Channel’ from ‘Discovery Communications LLC’ (2010). All information about ‘Discovery Channel’ was downloaded from the Internet. Because of the space limitations I only present one analysis here from one TV-channel. Then I compare what is broadcast on ‘Discovery Channel’ with the content orientation that is perceived relevant among the teenagers.

RESULTS

In the analysis I have picked out all the programs on ‘Discovery Channel’ that was broadcasted during one week from 1st of March to the 7th of March in Sweden. Among those, seventeen programs were excluded because of lack of good information (Table 1). Besides, many of the programs in Table 1 did not get much time in the programme schedule.

Table 1. Programs on Discovery Channel in Sweden that were excluded from the analysis because of the lack of good information.
Krig på skroten
Street Customs Berlin
Femmans växel Europa
Fiskefantaster
Från vrak till bubbla
Amerikanska hotrods
X-Machines
Factory Made
Gröna åk
Discovery Project Earth
Mega Engineering
Jag borde varit död
Syna bluffen
Fiskeäventyraren
Rally-VM: Bakom ratten
Extrema bilar
Årets värsta tornados

In the next step I put together eighteen programs with good information and that had their international correspondence, which means that they are broadcasted in several countries and reaches an international audience (Table 2). The short descriptions of the programs stems from official wordings on the Internet (Discovery Communications LLC, 2010) and chosen to give a sense of what the programs are about, what kind of questions they answer.

Several of the programs presented in Table 2 are given lots of time in the programme schedule.

Table 2. Programs on 'Discovery Channel' in Sweden with international correspondence presented with short descriptions.

How do they do it?	Just when you thought How Do They Do It? had told you everything you had ever wanted to know, Robert gives us answers to even more questions as he gets his down and dirty in his quest to understand modern technology.
Megabuilders	As the world's engineers and planners come up with new ways to solve the increasing demands of life on Earth in the 21st century, there are many amazing engineering projects taking place globally.
Mythbusters	Jamie and Adam are engineering and construction experts who combine science, special effects and technology to determine the validity of countless popular myths and legends through a series of tests and experiments. Welcome to Mythbusters - home of myths, science, experiments and explosions.
American chopper	Real bikes. Real fights. Real man hugs. This cult series tracks the daily tension, tirades and triumphs of a father and son team, as they run a business creating custom motorbike masterpieces.
How it's made	How articles for everyday use are made.
Miami Ink	Follow tattooists Ami James, Chris Garver, Darren Brass, Chris Nuñez, the glamorous Kat Von D and apprentice Yoji as they go about their business. Miami Ink challenges cultural stereotypes of skin art and illustrates the real talent behind the famed 'inkists'.
Time Warp	MIT scientist and teacher Jeff Lieberman - along with digital-imaging expert Matt Kearney - uses new technologies to bring truly never-before-seen wonders into a form that your body can actually process.
Dirty Jobs	Join Mike Rowe when he experience some of the planet's most dirty and dangerous jobs and meet the courageous people who perform these jobs every day.
Topp tio	For example the ten best fighter aircraft, the ten best tanks…submarines, choppers etc.
Chop Shop	See Bernie, Leepu and the team of master mechanics turn bangers into blingers. Supercars for superactors.
Industrial junkie	Jonny Smith take a closer look at how things are made, from oil drilling to super highway construction.
Born survivor: Bear Grylls	What does it take to be a true survivor? Adventurer Bear Grylls demonstrates in each episode, pushing his body (and gag reflex) to the limit. From skinning camels, eating a live snake and drinking water squeezed from elephant dung to building fires, setting up camp and navigating in the middle of the desert, when it comes to survival, nobody does it quite like Bear.
Huge Moves	Transfer of a big building
Storm Chasers	The latest season brings bigger, badder vehicles, monster hail storms and rivalries with other storm chasing crews. As if that wasn't enough, the team had a dream came true in the season finale, coming closer to a twister than ever before!
Destroyed in Seconds	From tower block implosions to rampaging tornadoes, catastrophic mid-air collisions to sudden terrorist attacks and dangerous races to stolen army vehicles, Destroyed In Seconds is the place for your fix of everything explosive.
Fearless Planet	A look at some of the planet's most amazing creations.
Survivorman	Living off the land takes on a new meaning when wilderness survival expert and filmmaker Les Stroud spends nine harrowing weeks in a variety of survival simulations. He takes off alone and heads to a punishing corner in the back of beyond with nothing but a few cameras to document his (often miserable) experiences
Wheeler Dealers	Video clips, photos and Mike and Edd's top tips on buying used cars. Learn how to restore a classic car to its former glory and get the best advice for buying used cars. Listen to these Wheeler Dealers and you might even be able to make a few quid yourself in the used car game.

In the continued content analysis I use results from the ROSE study in Sweden, presented in Table 3, showing the 20 first topics students want to learn about compared with what program on 'Discovery Channel' they can watch to have their wants stimulated.

Table 3. The 20 first topics in the ROSE questionnaire students want to learn about presented with means in falling order with standard deviation (SD) compared with what programs on 'Discovery Channel' that can be watched to stimulate those topics.

Topics in the ROSE questionnaire	Mean (SD)	Program on 'Discovery Channel'
How to exercise to keep the body fit and strong	3.03 (0.96)	Mythbusters, ***Born survivor: Bear Grylls, Survivorman***
How it feels to be weightless in space	3.00 (1.02)	Mythbusters
The possibility of life outside earth	2.93 (1.05)	
Why we dream while we are sleeping, and what the dreams may mean	2.93 (1.06)	Mythbusters
How different narcotics might affect the body	2.84 (1.00)	Mythbusters, ***Born survivor: Bear Grylls, Survivorman***
How alcohol and tobacco might affect the body	2.83 (0.98)	Mythbusters
What to eat to keep healthy and fit	2.81 (1.02)	Mythbusters, ***Born survivor: Bear Grylls, Survivorman***
What we know about HIV/AIDS and how to control it	2.80 (1.01)	
How to perform first-aid and use basic medical equipment	2.79 (1.00)	Mythbusters
Phenomena that scientists still cannot explain	2.77 (1.12)	Time Warp, ***Megabuilders***
Thought transference, mind-reading, sixth sense, intuition, etc…	2.77 (1.11)	
Sexually transmitted diseases and how to be protected against them.	2.77 (0.97)	
Cancer, what we know and how we can treat it	2.74 (1.03)	
How meteors, comets or asteroids may cause disasters on earth	2.71 (1.04)	***Fearless Planet, Destroyed in Seconds,*** Mythbusters
How my body grows and matures	2.69 (1.00)	
How computers work	2.69 (1.03)	***How do they do it?, How it's made,*** Industrial junkie
Sex and reproduction	2.68 (0.94)	
Black holes, supernovas and other spectacular objects in outer space	2.67 (1.11)	
How to protect endangered species of animals	2.65 (1.02)	
Unsolved mysteries in outer space	2.65 (1.12)	

The results show that many students are interested in questions concerned with diet and health, astronomy and cosmology together with modern technology and challenging diseases. Many of the topics that students are interested to learn about are in compliance with what is televised on 'Discovery Channel'. What are missing to have a full match are more health stories and cosmology.

DISCUSSION

The idea with this study is to put together some of the latest research concerned with students interest of science and technology and consider the matter more closely from a cultural perspective. Maybe, to give expression to students' voices and understand them as utterances of changing experiences due to modernization and globalization, is one important way forward in science education research. This implies an increased comprehension of what changing experiences entail for students' possibilities to learn science and technology when they encounter compulsory school. Even though there are many similarities in developed countries between 'what students want to learn about' and 'what media telecast to satisfy peoples wants' it is not possible with the data presented here to explain the results in a cause-effect relationship. There are several important methodological conditions that may have influenced the results. Yet, only with one single analysis and with simple statistics from the ROSE study, there are congruity between students' wants and media. As this is an ongoing project and kind of new perspectives within science education research, there are more detailed results to present in the future.

The point with this study is to turn the attention to media and specific science content and trying to understand people's engagement with science and technology from ways the content can be experienced outside school. Maybe 'science in society' can assist in understanding students' interest or disinterest for school science (Braund & Reiss, 2006). In this case, 'Discovery Channel' constitutes one example of what parts from science and technology that are brought out and how they are contextualized. Modern technology, how things work, mysteries, wonders, spectacular phenomena, myths and explosions seem to be important. Health issues are not that protruding on this channel as is the case with astronomy. But this is just a look on one channel on one week in Sweden. On the discovery home page there is information that because of NASA's 50th birthday, Discovery Channel is presenting a series of episodes of the space pioneering (Discovery Communications LLC, 2010).

Journalists and program makers present their stories in a way that make people continue reading or not to switch the channel. This is done from a cognizance of production as well as reception (Holliman, 2004). With societal development, several more actors will treat science and technology from the purpose of marketing certain content in narratives that make people want to participate (Dhingra, 2006). I argue that this could be one important factor behind the international similarities in young people's content orientation in modernized countries (Schreiner, 2006). With this study I contribute to this field of research by analyzing specific content and relating to informal science learning. Further studies are needed that pay attention to both formal and informal science learning and what those circumstances means for the experience of school science among youth in different societies. It would also be interesting to continue analyzing and compare with what content is focused in classrooms, curricula and teaching aids.

Students are not talking with one voice (Jenkins, 2006). What I present here is only a broad picture. Questions of ethnicity, gender and age are three examples of interesting continuations. Other methodologies are a second significant perspective. Thirdly, and maybe the most important, is a discussion of the purpose of science and technology as parts of education. I have not said that school science should be like media science. Especially as there is evidence that science in the media sometimes scare people instead of informing (Huxford, 2000). Maybe quite the opposite, school science can benefit from media (Salleh, 2001) and not trying to be in a competitive situation. To prepare people for citizenship should be the main purpose and public function of compulsory education. When science and technology affect everyone's life, it demands on the educational system to be updated and relevant. To handle media, to understand from what purposes stories are told and that many times, there are economical and political realities behind (Cottle, 2004) are of equal importance as learning some science facts. Science in the media is also the way most people will continue encountering those knowledge fields after formal schooling.

Modernization involved a strong development of communication media and can be traced back several hundred years. In spite of this production and the importance of how it affects people's lives, media studies have been marginalized in social science research and there are several reasons for that (Thompson, 2001).Thompson tries to develop a social theory of the media and one of the most important starting points in his account is that communication media are central in modernization and lead to a world where many experiences are mediated and separated from shared meeting places. In addition, there are many different actors who treat content in different stories from various purposes. People will have to sort through this and structure mediated knowledge in what is relevant from a personal point of view. By those processes, meaning making is not a static phenomenon. It is in constant movement and transformation (Thompson, 2001).

To reach people in a modernized world you will have to explain why they should care, anchoring announcements in people's wants and needs. Those are like new rules in the development of communication. In its basic sense, authentic science learning environments are strongly involved in the development of communication media (Roth, 1997) where mediated experiences reshape traditions. To develop learning environments, where products of a civilization can be discussed, reflected and contemplated is important if education should contribute to empowerment, international understanding and piece. The reversed order can be the feeling of being an outsider, which for science on compulsory level today, is true for many students

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A SYSTEMIC APPROACH TO SUSTAINABLE DEVELOPMENT ISSUES THROUGH SCIENCE EDUCATION

Chrysanthi Kadji-Beltran

Frederick University Cyprus

Assistant Professor

pre.kch@frederick.ac.cy

Costas Kadis

Frederick University Cyprus

Associate Professor

pre.kc@frederick.ac.cy

ABSTRACT

The current paper explores the potential of using a systemic approach to ESD issues within science education in order to acknowledge and integrate their social, cultural, environmental and ethical dimensions in the educational praxis.

A group of undergraduate teacher students was introduced to Sustainable Development concepts emerging from, or related to, the science curriculum through a variety of approaches and contexts and establishing links with their environmental, biological, ethical, social and cultural aspects. Using elements of participatory action research, the students were invited to discuss the systemic approach used, in terms of acquiring a holistic understanding of the concepts, the practical pedagogical value of the systemic approach, as well as any constrains observed during the implementation.

The objective of the paper is to discuss the use of the systemic approach as a means of linking science curriculum concepts with Education for Sustainable Development. Science curriculum can provide a basis – starting point for the study of several SD issues and establish links with other curriculum subjects in a pedagogically beneficial way. A systemic approach will enable the reunification of fragmented information and thinking and can help students understand profoundly and effectively the interrelations and interactions between SD issues and concepts.

Keywords: *Systemic approach, education for sustainable development, science education, sustainable development issues, programme development*

INTRODUCTION

Education for Sustainable Development emerged from Environmental Education but constitutes and embraces far more than its origin. Sustainable Development being at its centre, ESD engages in highlighting the links between environmental, social and economic issues, and expands on values-oriented issues such as democracy, social equity, peace, human rights and health. It focuses on (a) learning about the environment and its operation; (b) understanding the impact the environment receives from social, economic and developmental activities; (c) realising the environmental degradation; (d) considering sustainable approaches and solutions that can lead to its sustainable use as well as (e) developing skills and abilities for acquiring this knowledge. ESD also uses the environment as a “learning environment” for raising awareness and developing emotional ties that can turn individuals’ attitudes and actions towards sustainable life styles. Individuals are empowered so as to become carriers of this change and gatekeepers of a sustainable use of the natural resources in democratic and sustainable societies. It therefore constitutes a revolutionary form of education both in terms of content and implementation.

ESD is founded on critical and innovative thinking that can emerge in any context, any place or moment and promotes change and social and educational restructure. It supports social and ecological solidarity, social justice, responsibility, tolerance, and according to these values it processes sustainable development issues, man – nature relations and interactions and promotes democratic social changes through critical and participatory approaches (Flogaiti 2006).

The critical role of ESD as the means for promoting SD has been prompted by various conferences and official documents, for improving the capacity of people to address environmental and development issues (UNCED, 1992; UNESCO, 2002). The UNESCO Decade of Education for Sustainable Development seeks to achieve through education, a world where everyone has the opportunity to benefit from education, and acquire the values, behaviour and lifestyles required for a sustainable future and for positive societal transformation (UNESCO 2004, p.4).

Science education has an important role to play in education for sustainable development. When it comes to sustainable development concepts, traditionally perceived and treated as scientific, establishing links within disciplines is of even greater importance for the achievement of the global, holistic perspective of SD issues. Issues such as energy, biodiversity or water, form a traditional part of the science curriculum (Mueller M.P. and Bentley M.L., 2009). Students are often introduced to these issues through inquiry, scientific processes, skills acquisition and they learn about their content, their properties and related phenomena. Nevertheless these issues also need to be linked to social, cultural, economic and environmental implications or causes (Barret E.S. and Pedretti E. 2006). Science teachers consider that although their teaching can contribute the important knowledge and abilities required for ESD, it is not their role to inculcate in their students behaviour, attitudes or values (Gayford 2002). There is also an underlying concern that linking science to ESD might endanger the integrity of science education.

The common ground with ESD provides a unique opportunity for Science education, to take advantage of the ESD qualities that can enable the establishment of links with the social, cultural, environmental and ethical context. The synergy between science education and ESD can work in a way that can benefit both; it can enable the achievement of latent goals in science education and can provide a starting point for introducing ESD issues in the curriculum.

Due to the school organization and operation, primary education can easily facilitate the systemic, holistic and consequently integrative approach to SD and scientific issues. Primary schools are flexible in their programme and the teachers have the potential for distributing SD issues in the curriculum and establishing the required links. The existing flexibility of primary education for organizing and coordinating the integration of SD within the curriculum, eliminates any concerns for demotion of any discipline and contrary to that it contributes to their enhancement. This integration is nevertheless demanding for teachers, who feel more confident following the traditional educational schemas. Discipline oriented education received by teachers, impedes the acquisition of crosscurricular integration skills (Moslemi. J, Capps K., Johnson M., Maul J., McIndyre P, Melvin A., Vadas T., Vallano D, Watkins J. and Weiss M. 2009) and probably constitutes a gap in teacher education. It also reinforces the continuation of the segmented cognition and skills acquisition and limits a creative, critical, systemic way of thinking. Strict fragmentation of the disciplines and the boundaries between sciences, have also impeded the integration of ESD in the teachers' programmes of study. Despite the UNESCO (2004) recommendations about reorienting teacher education towards ESD as a key strategy in achieving a sustainable society, ESD is far from becoming mainstream and it is rarely addressed during initial teacher education.

Nevertheless teacher students, as future teachers, are expected to develop and deliver ESD through primary education curriculum in a holistic – cross curricular way and highlight the systemic character of SD issues. They will be asked to identify the scientific, social, cultural, environmental and ethical dimensions of the SD issues and effectively re-establish the links that will assemble the greater picture. Yet, it is highly unlikely that their subject oriented teacher education experiences have enabled them to do so.

The systemic approach is a new trend of thought, with an unspecified breadth. It does not suggest a new body of knowledge but it seeks restructuring the organization and operation of our intellectual activity. It is an inherent element of education for sustainable development due to the complexity and multiplicity of the issues it engages with.

The Systemic Approach derives from a "non-analytical" way of thinking. The Analytical way of thinking lead to a compartmentalisation of knowledge and studied in depth the "section" and ignored the whole. This approach ignored the interconnections of the parts and the additional properties attributed to a system due to these connections and entailed the risk of drawing erroneous or inadequate conclusions. The development of individual scientific areas was based on this way of thinking. The non-analytical approach accepts that reality emerges from the interconnectedness and interactions rather than the isolation (Stranga 2006).

Systemic thinking is the way of approaching the "whole". It enables the learner to obtain a better understanding of the connections rather than the sections and recognise change and evolution over stagnation. The learner identifies the different dimensions and elements of the issue, highlights the relations and interactions of these elements, distinguishes their emerging properties and can analyse their meaning and importance within the structure and dynamics of the system they compose (Flogaiti 2006). As an approach to education, the systemic approach is slow but it has a lasting impact (Benedict, 1999). Therefore the systemic approach can lead to the "transition from *first-order changes* that are superficial and short term to the *second-order changes* that affect the culture and structure of the schools and are slow but long term" (Fullan and Stiegelbauer 2001). The systemic approach therefore holds the potential of enabling the achievement of change as this is sought by ESD.

Besides being a key characteristic of ESD, systemic thinking is a valuable approach to science education since it can facilitate the achievement of objectives that are overlooked by a purely scientific approach. Science education embraces beyond scientific literacy, goals that promote sociopolitical, civic and democratic competencies as well as ethical purposes (Yoon, 2008). Nevertheless education is currently segmented within disciplinary lines and each discipline has its own paradigms, quality standards and vocabulary (Benedict 1999). Linking the context of science concepts to their social, economic, environmental as well as ethical and cultural dimensions is a science education goal that is rarely acknowledged and often overlooked, since these goals are attributed to social sciences (Huges 2000).

RATIONALE OF THE RESEARCH

Our hypothesis was that using the scientific context of ESD issues as a starting point, students could continue their study of the same issues through different perspectives: environmental, social, ethical, economic and cultural. Therefore students would be introduced to the systemic, holistic approach of these issues and acquire practical pedagogical experiences and skills that would raise their self efficacy for integrating ESD issues in the curriculum and becoming able to link science to its marginalised goals and qualities.

The research was developed as part of the self evaluation process of a new optional module offered to third year undergraduate teacher students. Additionally it addresses issues concerning the potential use of the systemic approach in highlighting the links between the science curriculum and ESD.

PURPOSE OF THE RESEARCH

The general purpose of the research is to examine the potential of the systemic approach for linking science education concepts to their non-science oriented context. This is achieved through exploring students' perceptions about the systemic approach, science education, education for sustainable development and the perceived connections between the three. The research also examines students opinions about the difficulties posed by this approach and also seeks to identify the benefits that the students see in the systemic approach. Students' self efficacy for a systemic - integrated approach to ESD is also examined.

The research questions addressed were:

(1) How do students understand the systemic approach and its educational value with respect to science education and ESD?
(2) How do students perceive the connection between ESD, Science education and the systemic approach?
(3) Which practical implications arise from the use of the systemic approach in the teaching process, for linking science education to ESD issues?
(4) Which is students' self efficacy in using the systemic approach in the context of ESD and science education and how can it be enhanced?

METHODS

The educational intervention - The module

The module was an optional module, specialising on ESD and Science Education. It was designed in order to help students acquire a systemic way of thinking, realise the interrelations and interactions between scientific, social, cultural, environmental and economic aspects of SD issues within the science curriculum and develop the skills that would be needed in order to develop and deliver ESD and science education concepts in schools, in a systemic integrative way.

Its objectives and outline were set by the instructor, but students were invited to participate in its development by providing feedback about the theory, the concepts and the methodology of the module's delivery. Students had already attended two science education modules and two environmental education modules.

The ESD and Science optional module started with informative meetings on ESD and introduction to science education in order to refresh and ensure the existence of the basic required knowledge. They were also introduced to systems thinking and the use of the systemic approach in teaching.

Theory was put into practice when students engaged in the study of a number of science / SD concepts through a systemic design and holistic approach (energy, water, biodiversity). Based on constructivism theory, each unit begun with brain storming and concept mapping techniques in order to reveal students' existing ideas and thinking biases about the concept. This process was later on reviewed and elaborated in order to constitute the basis for the development of the lessons that followed. Additionally to the scientific approaches used for the study of the concepts (inquiry, explorations, scientific processes), other pedagogical activities were used (role play, debate etc) in order to establish the sought connections with social, cultural, environmental and economic, aspects of the issues, and draw from a variety of disciplines; arts, humanities and social sciences.

The module delivery was completed in January 2010 and research was conducted after the end of the examination period so as not to pose ethical issues concerning students' evaluation and enable a more objective and sincere participation in the research.

The sample

The group of students attending the optional lesson, was small (8 students), which was approximately one third of the third year students' population. This is due to a transitional period of departmental transfer to a different campus. All the students attending the module were invited to participate to the interviews and six of them accepted the invitation.

The instrument

The interviews were conducted by a trained thesis student in order to avoid the instructors' – researchers' involvement as this was likely to influence the way the students would respond to the questions. The use of a structured interviews protocol was considered to be suitable for our circumstances, since it would be easier for the student - interviewer to conduct. The interviews were conducted anonymously and followed a pre-structured protocol, which is included in the appendixes of the paper. During interviews students had the opportunity to discuss their experience of the lessons. They were asked to express their opinion on the module development processes, the teaching techniques used, the benefits and drawbacks they observed and finally to offer their suggestions for the improvement of the module and discuss their self efficacy for putting what they learned (information and pedagogical skills) into practice.

The analysis

Interviews transcripts were qualitatively processed by means of document review and analysis. During the review, we considered the answers to each protocol question. Some of these answers were synthesised in order to form the broader categories which are discussed in the results part.

Limitations of the research

We acknowledge that the sample participating in the research was small, nevertheless this was due to the limited number of the overall 3rd year student population. This group was the 1st group to attend the new module and therefore were the only ones eligible to participate in the research. In-depth interviews and the use of qualitative analysis was the most appropriate research approach due to the existing conditions and limitations. Therefore we have to acknowledge that the outcomes of our research can by no means be generalised. They will be useful for the educators and programme developers for the improvement and possible modification of the module offered and can form the basis for future research.

RESULTS

Students' understanding of the systemic approach and its educational value

Overall, the students appeared to have acquired a good understanding of the concept "systemic" as they were able to define and explain it. They considered that "in education, the systemic approach is a methodological approach, through which individual parts of a system as well as their interrelations and interactions are studied in order to acquire an understanding of the whole". Through the explanations given, it was evident that students' perceptions on the systemic approach connected it to the integrative cross-curricular approach, due to the reunification of a number of disciplines.

Its educational value was acknowledged by all students, although they did not identify or argue about the same benefits. One of the students considered problem solving skills, a benefit resulting from the use of the systemic approach. The same student, argued that the systemic approach can help pupils acquire a synthetic way of thinking by being able to draw information from a variety of disciplines and critically process the collected data. According to students' opinion the established links between disciplines can also enable learners understand practical, real life implications of the concepts under study

Students' understanding of the connection between Systemic Approach, ESD and Science Education

Students acknowledge that the systemic approach can help learners acquire a holistic understanding of natural phenomena and environmental issues. The identification of the different dimensions and elements that constitute an issue, and the examination of the interactions and the collective and individual properties of the parts, can highlight its meaning and importance. They also consider that systemic approach is valuable for science education as it enables the collection and organisation of knowledge and can lead to solutions for the scientific problems of modern life. The fact that systemic approach established links with the social implications of scientific issues was considered an additional benefit for science education. Further on the holistic context might be more appealing for pupils. Finally students discussed that the potential of the Systemic Approach for establishing connections to real life situations can better attract pupils' attention and can link teaching and learning process to students' personal experiences and interests.

The same benefits were acknowledged for ESD. Nevertheless, for some of the students the systemic approach could also result to raising awareness and environmental sensitivity although this attribute was not acknowledged as a benefit for science education. Awareness raising and values development was attributed to the engagement with other disciplines for the systemic examination of the taught concepts.

Implementation Difficulties

The systemic approach was apparently a concept difficult to assimilate, both in terms of context as well as a pedagogical approach. Its practical use in teaching specific concepts during the module delivery was the key to enabling the students understand what the systemic approach was about.

One of the students identified that within the Systemic approach underlies the risk of becoming superficial in approaching any concept. Broadness was considered to put at risk detail and depth. As the same student pointed out an effective use of the systemic approach requires teachers who are trained in a wide range of disciplines and equipped with a wide range of pedagogical skills. This was considered to be essential in order to provide detailed and accurate instruction as well as link all the aspects of the concepts studied.

The organisation and coordination of the “parts” was also mentioned as one of the identified implementation difficulties. Consequent to the systemic approach, the integrative approach, appears to be a complex quest for the students; they express multiple reservations concerning extracurricular activities and pedagogical skills, a demanding curriculum work load and as a result the limitations in time. They consider that in many cases, the systemic approach, results to engaging into extracurricular issues and activities which can indeed enhance the current curriculum but simultaneously can impose additional workload to the teachers and diminish the time available for implementing the official curriculum.

How can students’ self efficacy be reinforced?

Although students did not feel incompetent for using the systemic approach for teaching and learning, they neither appeared to feel too competent using it. They acknowledged the pedagogical value of the systemic approach but some of them were still unsure about its use. One of the students explicitly expressed the need to develop a clearer understanding of the planning and implementation process. The use of the approach by the trainer, for the delivery of science education SD concepts was considered to be very useful as it set an example for the students and helped them understand the planning and implementation process. Still students seemed to be in need for more such pedagogical experiences.

Students appreciated most, the activities which enabled them to engage in practical teaching in the classroom. The familiar and friendly classroom environment, with their peers, was considered to be ideal for planning and teaching small lessons on SD concepts following the systemic approach. The interaction with their peers and the discussion of the delivered classes offered them valuable feedback.

Students commented that all stages followed within the module were necessary, followed a rational time sequence and helped them understand the approach, its educational value, the process to be followed for the planning and finally the organisation and delivery of the classes. They requested more practical activities and more opportunities for microteaching, although they could not cancel or restrict any of the module's elements.

DISCUSSION

Environmental degradation and the promotion of ESD for the development of sustainable lifestyles have created a growing need for scientists who have the skills and expertise to tackle the enormous complexity of contemporary environmental problems. The development of such scientists requires training that cuts across traditional disciplinary and methodological lines (Moslemi, *et al*. 2009) and has implications for teacher education (Martin, Brannigan and Hall, 2005). In the case of teacher education, there is an apparent need for reconsidering the programmes offered (UNESCO 2004).

Initial teacher education provides a clear view of the content and pedagogy of individual disciplines raising students' efficacy to teach the respective curriculum lessons (Intrador, 2006). It is nevertheless inadequate when it comes to delivering integrative educational innovations such as ESD and this, results to a limited self efficacy of the teachers to implement ESD in schools.

Within teacher education programmes, Science Education is the discipline with the most obvious connections to ESD, (apart form any specialized ESD modules) and in many cases it is the only available discipline that can contribute to ESD. Nevertheless, teacher students and teachers, as indicated by research (Gayford 2002) have difficulty in connecting science education to the social – ethical – awareness raising aspects required by ESD. The moment these links are established, the lesson is no longer perceived as science education but some area of social sciences. Science teachers need to find ways of maintaining the integrity of their chosen discipline and at the same time contribute to ESD. Although this is not an issue within primary education, it is raised as a major issue in teacher education.

Reorienting teacher education towards an integrative programme of studies poses practical limitations and holds the risk for superficial instruction, with coordination difficulties. Even aligning subjects or disciplines in parallel schedules or units does not necessarily offer integrative experiences to the students (Thompson–Klein 2005). Simultaneously solid knowledge in the various scientific fields is a key objective of teacher education so as to produce competent educators. Taking these as facts, how can teacher education produce the multi-skilled scientists needed for ESD?

Enhancing collaboration and integration of knowledge across traditional disciplines has been often discussed (Martin et al., 2005; Paige, Lloyd and Chartres, 2008) and it would be interesting to explore the extent this could take within teacher education programmes. Nevertheless, we have to acknowledge the practical hindering factors and limitations of such an approach within higher education. Research outcomes indicate (a) the need for training the trainers; (b) the existing need for safeguarding ones' disciplinary territory; (Gayford 2002) (c) the need of higher education for in depth learning as opposed to superficial learning; (d) coordination difficulties; (e) discipline priority and marginalisation of ESD; (f) accreditation difficulties (Martin et al., 2005). One of the possible solutions of bridging this gap in teacher education is the establishment and provision of integrative modules that can enhance and reinforce the students' skills so as to be able as future teachers to establish transdisciplinary links to ESD.

Our research considered the potential of science education for opening the gates for ESD and exploited the systemic approach as a common approach that could link science education to ESD. Starting with the scientific context of ESD concepts, the systemic approach facilitated the connection to social, cultural and ethical implications which are not perceived as relevant to science education and assisted the achievement of latent goals of science education. Further on it offered opportunities for engaging in pedagogical and methodological approaches that differ to the ones frequently adopted by science teachers (Gayford 2002), enhancing therefore teacher students' pedagogical skills and abilities. Despite their contact with the approach and the understanding they developed concerning its context, its practical use and value, students still expressed reservations about its use in primary education. These reservations concerning the systemic approach can be anticipated and justified if we consider that teacher students are still developing their pedagogical skills, learning to manage time, organise and manage the classroom, becoming familiar with the use of methodological approaches and building up content knowledge on a number of disciplines (Luft 2007).

Microteaching activities, engaging students in practical teaching, were commented to have positive impact on students' self efficacy. Nevertheless students stressed the need for more such opportunities. This outcome has implications concerning teacher training programmes' ability to provide practical teaching skills through real experiences with respect to the structure of the modules taught as well as students' opportunities for teaching practice in schools. It would be interesting, in future research to explore students experience of lessons elaborating ESD concepts in a systemic way in schools and the opportunities they have to teach ESD / science concepts using the same approach.

Implications and challenges for the future

We have to acknowledge that the outcomes of the research can have practical use only for the improvement and revision of the specific module. Nevertheless results are relevant to teacher education in general, science education and ESD. The use of the systemic approach as a vehicle that can link ESD to curriculum disciplines and enable the creation and delivery of integrative modules seems to be promising and beneficial for promoting ESD within teacher education programmes and enhancing science education. Future research can scrutinise the potential of integrative ESD modules for enhancing teacher students' pedagogical skills and methodological abilities and raising their self efficacy in ESD and explore possibilities for augmenting the number of opportunities for experiencing and practicing teaching ESD during teacher education.

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APPENDIX A

The interviews protocol

1. Please explain what you understand about the term systemic approach.

2. Which is your opinion of the educational value of the systemic approach?

   (a) extremely worthless, (b) worthless, (c) neither valuable nor worthless, (d) valuable, (e) extremely valuable

3. In which of its attributes do you identify its pedagogical value? (What does the systemic approach offer to education?)

4. What does the systemic approach offer to science education?

5. What does the systemic approach offer to education for the environment and sustainable development?

6. Which difficulties could arise during the use of the systemic approach in school?

7. In which degree did you use this approach in order to plan and deliver the lessons for the microteaching? (1: approach was not used, 2: limited use, 3: slightly used, 4: very used, 5: extremely used) Describe how you worked.

8. Discuss your experience in the class. Which aspects of the module you found difficult, and which aspects benefited you the most?

9. Would you use this approach at school? How competent do you feel to do so? (1: Extremely incompetent, 2: incompetent, 3: neither competent, nor incompetent, 4: competent, 5: extremely competent). Why?

10. What do you think about the way that you were introduced to the concept of systemic thinking and systemic approach?

11. Is there something that you would like to change? What? In which way?

12. What is you opinion about the methodology used during the module, in order to enable you to use the systemic approach in teaching scientific and ESD concepts?

13. Is there something that you would like to change? What? In which way?

UNDERSTANDING OF DC-CIRCUIT PHENOMENA IN DIFFERENT AGES

Veera Kallunki

Department of Physics

University of Helsinki

veera.kallunki@helsinki.fi

Jari Lavonen

Department of Teacher Education
University of Helsinki

jari.lavonen@helsinki.fi

ABSTRACT

The aim of this cross sectional pilot study is to analyse the development of external representations of DC-circuit phenomena by interviewing 3rd, 6th and 9th graders at Finnish compulsory school. The study is a national level preliminary study of an international research project in learning DC-circuit phenomena. The project aims at producing comparable and generalisable information on the development of students' external representations of DC-circuit phenomena, and their learning processes in the domain. This study aims to offer information for the design of a novel tool and method for analysing the development of external representations of DC-circuit phenomena.

Earlier studies have reported difficulties in understanding this abstract topic. The learning difficulties typically occur in the qualitative understanding of DC-circuit phenomena. According to earlier studies, although pupils can solve quantitative problems, they do not understand how circuits function qualitatively, nor can they apply the learned concepts to a concrete circuit. However, it has been reported that the external representations evolve in relation to given instructions, and the age of the pupil; the older the pupils are, the more scientific are their representations.

According to the results of this study, development occurs in the external representations of DC-circuit phenomena. Surprisingly, the interviews with the 6th graders proved to be the most fruitful. Moreover, it is surprising that all age groups seem to understand more qualitatively the functioning of the electric circuits than reported earlier. Their external representations include correct fragments of different DC-circuit connections.

Keywords: *learning process of DC-circuit phenomena, age, and instruction.*

INTRODUCTION

Understanding the DC-circuit phenomenon has been found to be difficult and abstract for pupils (Gunstone et al. 2009; Mulhall et al. 2001). Many researchers, like McDermott and Shaffer (1992) have reported that pupils of varying ages have problems in understanding DC-circuit concepts or working with electric circuits. The learning problems typically occur in the qualitative stage of DC-circuit phenomena. Although pupils can solve quantitative problems, they do not understand how circuits function qualitatively, or what the influence of different components is on the source voltage, and the electric current. Nor can they apply the learned concepts to a concrete circuit. In this study, the research question was set as follows: How does pupil's external representations of DC-circuit phenomena develop in relation to her/his age, and given instructions in Finnish compulsory school?

This research is a national level preliminary study of an international joint research project. The next step is the development of a novel analysis tool, and method that will be used to study how the external representations of DC-circuit phenomena develop in compulsory education.

PUPILS' EXTERNAL REPRESENTATIONS OF DC-CIRCUIT PHENOMENA

The extensive research literature discussing conceptual understanding and learning of DC-circuit phenomena has revealed pupils' external representations of DC-circuit phenomena. The term "internal representation" instead of "mental model" has been used recently to better describe pupils' tentative phase of modelling. In proportion the use of "external representation" has become general. In this study, the term external representation is used because it better describes the tentative nature of these models (Gilbert, Justi and Ferreira 2007).

The representations have been concerned with DC-circuit phenomena and the concepts of the electric current, the source voltage, and the electric circuit. For example, in Shipstone's (1984) study, it was found that the main misunderstanding in the pupils' representations was the nature of the electric current: Is there one or two opposite electric currents? Where does the electric current come from? Is the electric current consumed or conserved in the circuit? How does the structure of the circuit affect the electric circuit? Is the electric current some kind of material? Moreover, the students have difficulties in understanding the bipolarity of the components, and the role of the wire: Is only one wire from the battery enough? Why does the bulb glow? What happens in the wire when the bulb glows? The role of the battery varies: Is it a source of a constant electric current? Where does the electric current come from? What is the relation between the electric current and the source voltage?

According to Borges and Gilbert (1999), the external representations evolve in a commensurate manner with the instructions given to the subjects. Also Cosgrove et al.'s (1985) study showed that the external representations evolved in relation to the age of the pupil; the older the pupils, the more scientific their representations were. This correlation between age and quality of the representations seems natural, and it appears also in Borges' and Gilbert's (1999) models. The age–representation relationship includes the level of instruction because in both studies the subjects were taught in physics. In earlier studies the external representations of DC-circuit phenomena have been studied among different age groups. For example Cosgrove et al.'s (1985, 249) study examined 10–18-year-olds' external representations of circuit phenomena, Tsai et al.'s (2007) 13–16-year-olds', and Kallunki's (2009) 9-year-olds'. In the present study, the particular focus is on the development of the external representations of DC-circuit phenomena.

METHODS

Cross sectional qualitative study with the target group of students from 3rd, 6th and 9th grades of Finnish comprehensive school was executed in May 2009. The pupils were 9, 12 and 15-year-olds at the time. These particular grades were selected because electric circuits are taught in these grades. The data for this pilot study was gathered by interviewing two pupils from each of these three age groups. The number of pupils was limited to six because of the preliminary nature of the study. It was assumed that this number of pupils offer enough information for the further development of the preliminary analysis tool and method. The pupils were selected by the teacher, and the teacher was asked to select students achieving median grades in science.

The interviews were based on pictures of electric circuits, and pupils were asked to explain different situations. The interview protocol was developed in collaboration with an international research team, and it was based on Chiu and Lin's (2005) study. In the interview protocol, for example, a picture was used to describe a situation, where one battery and one bulb were connected with two wires. Then the students were asked: "What happens if another battery is coupled in series with the first battery?" The students were also asked to draw a new figure, and then give arguments for their statements. The interviews were transcribed and analysed using theory driven content analysis.

RESULTS

The results showed that there does occur development in the external representations of DC-circuit phenomena through the level instruction and maturation of the students. The development of the external representations of the electric circuit, the electric current, and the source voltage will be described here in detail. Firstly, the external representations of each age group will be presented with so-called fragment maps (see Figure 1, Figure 2 and Figure 3), which uncover the developing fragments of the main concepts. Secondly, the fragment maps will be compared in proportion to age group. In these maps the fragments of the electric circuit are marked by circular boxes, the fragments of the electric current by pentagons, and the fragments of the source voltage by diamond patterns. As mentioned above, two pupils from every each group were interviewed. So, in the fragment maps the united opinions of the two pupils are marked by compound lines. In proportion, the conceptions that only the other pupil has expressed are marked by dash lines.

GENERAL RESULTS

The general view of the external representations of DC-circuit phenomena among interviewed pupils is that they seem to understand the functions of the electric circuit surprisingly well. Against the reported difficulties in learning about electricity, the interviewed pupils were able to explain and predict qualitatively different situations of DC-circuits. Moreover, the explanations given were more empirically based than theoretically based, which means that learning was clearly experimentally oriented. This finding encourages in developing similar research method to uncover real learning (see Figure 1, Figure 2 and Figure 3).

EXTERNAL REPRESENTATIONS OF 3RD GRADERS

The youngest age group of this study was the 3rd graders. The pupils said in the interview that they had constructed electric circuits in the handicraft lessons. Otherwise they had not been taught DC-circuit phenomena yet. The most divergent thing in the fragment map (see Figure 1) of third graders is that it does not yet have so many different fragments. The five fragments describe an open electric circuit, where only one wire is needed. The light from the bulbs is understood as an effect phenomenon of electricity.

According to 3d graders, the brightness of the bulb depends on the electric circuit. If there are two "own" wires for each bulb, they all shine equally brightly. In practice this means connecting the bulbs in parallel. Using the same logic the bulbs in series shine dimmer. It is interesting that in this phase the explanation is purely empirical or technical instead of generally reported theoretical explanation.

In the case of fragments of voltage, the third graders have a similar conception of the origin of electricity with both the 6th and the 9th graders. In all age groups the battery was described as the source of electricity or energy that flows to the bulbs.

Generally speaking, the fragment map of the 3rd graders is the most unambiguous: the two pupils share all except one of the five fragments.

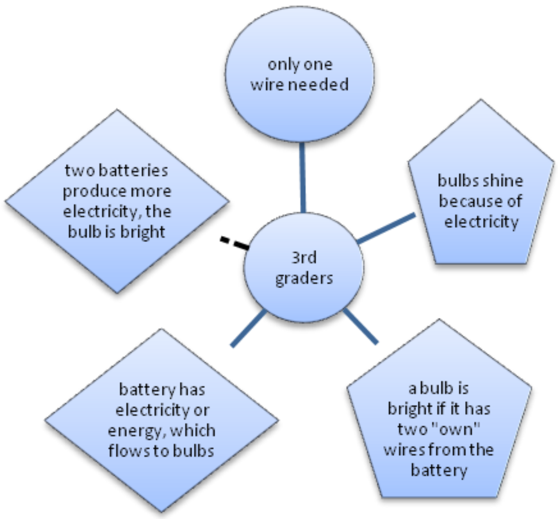

Figure 1 The external representations of 3rd graders of DC-circuit phenomena.

EXTERNAL REPRESENTATIONS OF 6TH GRADERS

The interviews were done in the late spring, just before the end of the spring term. Accordingly, the two interviewed 6th graders had learnt everything what is supposed to be learnt in lower classes. Compared to the 3rd graders' map, there are more fragments in the 6th graders' map (see Figure 2). The electric circuit is almost complete, and only very strictly speaking, there is a minor lack in the circuit. Namely, the structure of the bulb as a part of the electric circuit is still unclear.

As a new fragment the 6th graders suggested conductivity as the explanation for the lighting of several bulbs in series. They also described the movement of electricity using the expression "circulation". As in the 3rd graders fragments, also the 6th suggested the need of two "own" wires for several bulbs in series to produce as bright light as with a single bulb. However, there also appeared to be a conception of electricity consumption as the reason for dimmer lights.

The earlier developed fragment of the battery as a source of electricity had evolved. Both pupils described that the battery has special power. They had a clear picture that batteries in series brighten the bulb. The other pupil even understood the light of the bulb as a measurement of the source voltage.

Although there were more differences between conceptions of the two 6th graders than in the younger age group, the general view of DC-circuit phenomena seems to be quite well-balanced and empirically based.

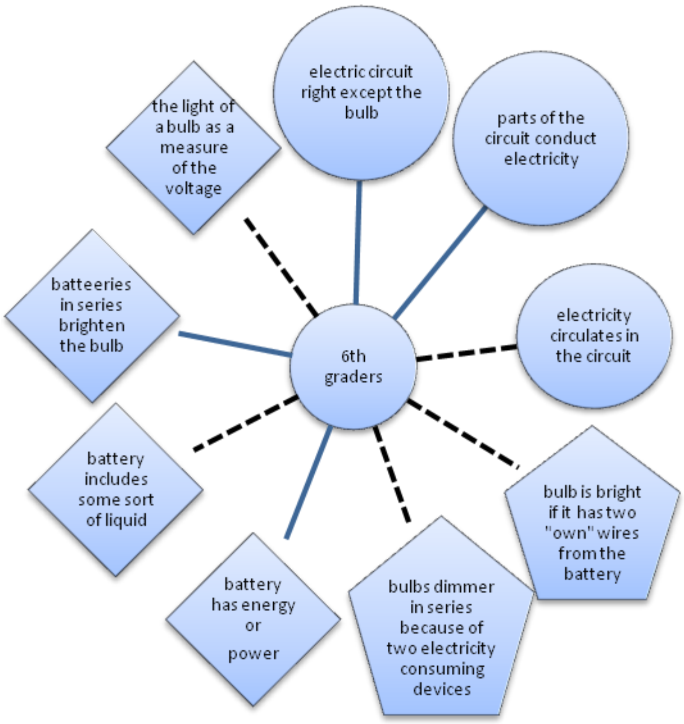

Figure 2 The external representations of sixth graders of DC-circuit phenomena.

EXTERNAL REPRESENTATIONS OF 9TH GRADERS

The fragment map of the 9th graders (see Figure 3) represents the level of concept formation of DC-circuit phenomena after the comprehensive school in Finland. The general view of the map shows that there is more scattering in the development than in the younger age groups. For example, the fragment “connecting bulbs in series is not possible” is quite undeveloped, where as the fragment “the number of batteries as measure of voltage” is well-developed.

There are also other developed fragments. For the first time, the electric circuit is comprehended fully as interview with the other 9th grader shows. The 9th graders still have the conception that the electric current is divided between the bulbs in series. Surprisingly, term “electric current” was used for first time in the interviews with the 9th graders.

The earlier reported electricity–energy–power property of the battery had evolved into voltage. At this phase, the other 9th grader even had a clear picture of the number of batteries as a measurement of the source voltage.

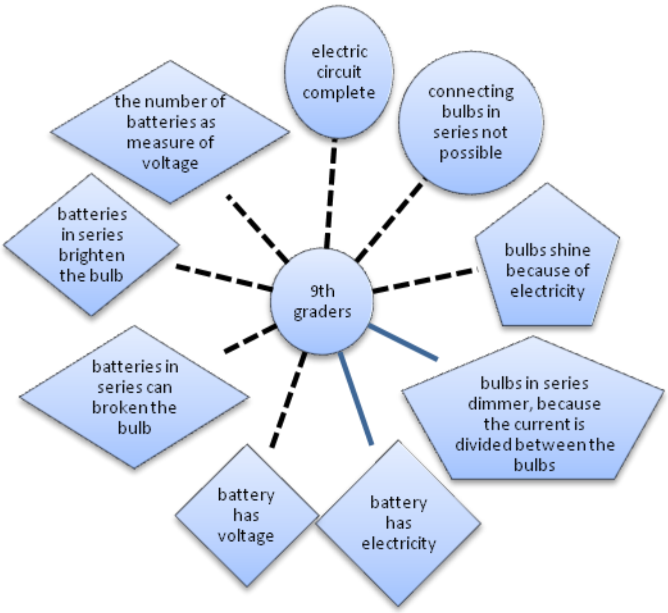

Figure 3 The external representations of ninth graders of DC-circuit phenomena.

CONCLUSION

The results of the study challenge the results of previous research into the abstractness and difficulty of electricity concepts. According to this research, the external representations of DC-circuit phenomena clearly developed along with the level of instruction and maturation of pupils. Surprisingly, the interviews of the 6th graders proved to be the most fruitful. Furthermore, the fragment maps uncover that although the theoretical explanations of DC-circuit phenomena, which have been obtained as results of typical mental model studies, remain undeveloped, learning at the qualitative level of understanding does take place.

This national level preliminary partner study as a part of an international joint research project gives some background data for developing a novel method for analysing how pupils' understanding of electric circuit develops. The next step will be to use diagrams similar to what cladists use (cladograms). The diagrams will show the development of the students' external representations of DC-circuit phenomena, and their learning processes in the domain in a similar way as cladograms represent the evolutionary tree of life.

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DETERMINING THE CONCEPT IMAGES OF THE STUDENT ABOUT DIRECT CURRENT CIRCUIT BY REPERTORY GRID TECHNIQUE

Şebnem Kandil INGEC

Gazi University

singec@gazi.edu.tr

Rıza SALAR

Gazi University

rizasalar@gmail.com

ABSTRACT

Education is one of the many application fields in which the Repertory Grid Technique (RGT) is employed. It is used in order to determine what students learn, and more importantly, how they learn. This study made utilize the RGT as an alternative evaluation tool to reveal the cognitive structures of the students about direct current circuits and conflicting ideas. “Rating” method was employed for data gathering, which was necessary to construct the repertory grids. The research was conducted with the physics teacher candidate. 10 elements related to direct current circuits were selected and these elements were translated into physical grids that the students could comprehend by the researcher. The participants were asked to fill in the grid by means of rating from 1 to 5. The computer program named GRIDSUITE and qualitative methods were followed in the analysis of the participant grid. It was found out that the RGT provides detailed information about the concepts. It was concluded that the repertory grid is a practical conceptual evaluation tool for direct current circuit. It is concluded that RGT is a convenient tool in assessing declarative and procedural knowledge in science education.

Keywords: *Repertory Grid Technique, concept image, direct current circuits.*

INTRODUCTION

The lack of satisfactory provision of novel ideas to students causes the development of conflicting ideas during their cognitive development period. This might result in conflicts between new and old ideas, which would then become an obstacle against effective learning. Thus, it is crucial for efficient education to detect the concept images and the conflicting ideas of the students.

Despite the inefficiency of the classical measurement and evaluation techniques in obtaining concept images, application of the techniques originally employed in psychology for education enhanced our perspective and measurement capability largely. One of them is the Repertory Grid Technique. Promoted (RGT) originally by Kelly (1955), this technique is employed to reveal the concept images of people.

Constructs, as the concepts they reflect, represent a dynamic system that displays the conceptual changes of an individual (Shaw and Gaines, 1993). This approach is a research method suggested to study the students’ conceptions and conceptual changes. This technique refers to both nomothetic and idiographic concerns (Wandersee, Mintzes and Novak, 1994). Using an approach based on the Repertory Grid Technique might serve as a tool in evaluating the evolution of the conceptual framework of an individual about a certain field.

Education is one of the several fields in which repertory grid is utilized. It is employed to determine what the students learn, and more significantly, how they learn (Jankowicz, 2004). The RGT is efficient in revealing the concept image used to define the whole cognitive structure related to the concepts (Aztekin, 2003).

The Repertory Grid technique could prove to be useful in investigating whether the thoughts of students are conflicting or coherent. In a study on the science concepts of students, Fetherstonhaugh (1994) used the RGT to examine the thoughts of high school students on different energy types. It was seen that the method was successful in revealing the width and depth of the opinions and relationships between them. Moreover, in their study on force and motion, Winer and Abend (1995) found out that the Repertory Grid was effective in monitoring the conceptual change among the high school students. Aztekin, Arikan and Sriraman (2010) propose repertory grid methodology as a way of capturing the constructs of students and argue that this methodology can help us to learn further details about the understanding of infinity.

AIM OF THE STUDY

This study sought to determine the concept images about short circuit, electrical potential difference, current, and the related perceptions, misconceptions, and pseudo-concepts. In addition, it aimed to contribute to determining the educational interest which is necessary to overcome the difficulties that students face in electricity topics. Moreover, the results would be useful to evaluate the RGT since the RGT is used to reveal the structures related to electricity.

METHOD AND PROCEDURE

Examining the RGT and applying it to the topic of electricity of physics class, this study used qualitative research methods and the computer program GRIDSUIT.

There are two ways of determining constructs in the RGT. The most common one is comparing two elements selected from the list of elements related to the topic to observe the similarities and differences, and determining with what construct it would be integrated. On the other hand, the second method asks the participants only to compare and contrast two elements. In both cases, the result is a 2-pole construct indicated by one of the two compared elements. The present study used the latter. The researcher chose the structures in order to examine especially the concepts of short circuit, electrical potential difference and current.

PARTICIPANTS IN THE STUDY

The research was conducted with a physics candidate teacher. The participant has just completed the 5-year undergraduate program of physics teaching at faculty of education.

THE REPERTORY GRID TECHNIQUE

Personal Construct Psychology is an individual and group psychosocial process theory, used extensively in modeling the cognitive processes of humans. Personal constructs are the basic units of the theory of personality, formally presented as a whole in The Psychology of Personal Constructs (1955) by George Kelly, a clinical psychologist who lived between 1905 and 1967. This work is a two-volume book that defines Personal Construct Psychology. Kelly used the RGT in this book. This grid is a matrix composed of elements and constructs, which is compiled by the participants by means of rating. The elements could be persons, institutions, objects, thoughts or events, whereas the constructs express the similarity, contrast and the relation between the elements and have a pole structure (good-bad, correct-incorrect, potential difference exists -potential difference does not exist). There are several ways to determine the constructs. In general, the researcher and the interviewee decide them together. However, the researcher alone can determine the constructs as well, which may result in the inflexibility of the grid. RGT retains the flavor of qualitative methodology while at the same time providing the opportunity for quantitative analysis. (Aztekin,Arikan and Sriraman, 2010)

THE RESEARCH INSTRUMENT

In particular, the concepts of short circuit, potential difference and current were underlined and 10 elements were selected. The elements are presented in Table 1. These elements were then translated into physical grids by the researcher in a way that the students could comprehend. The researcher determined the relevant constructs for the selected elements. The constructs are presented in Table 2.

Table1. Elements

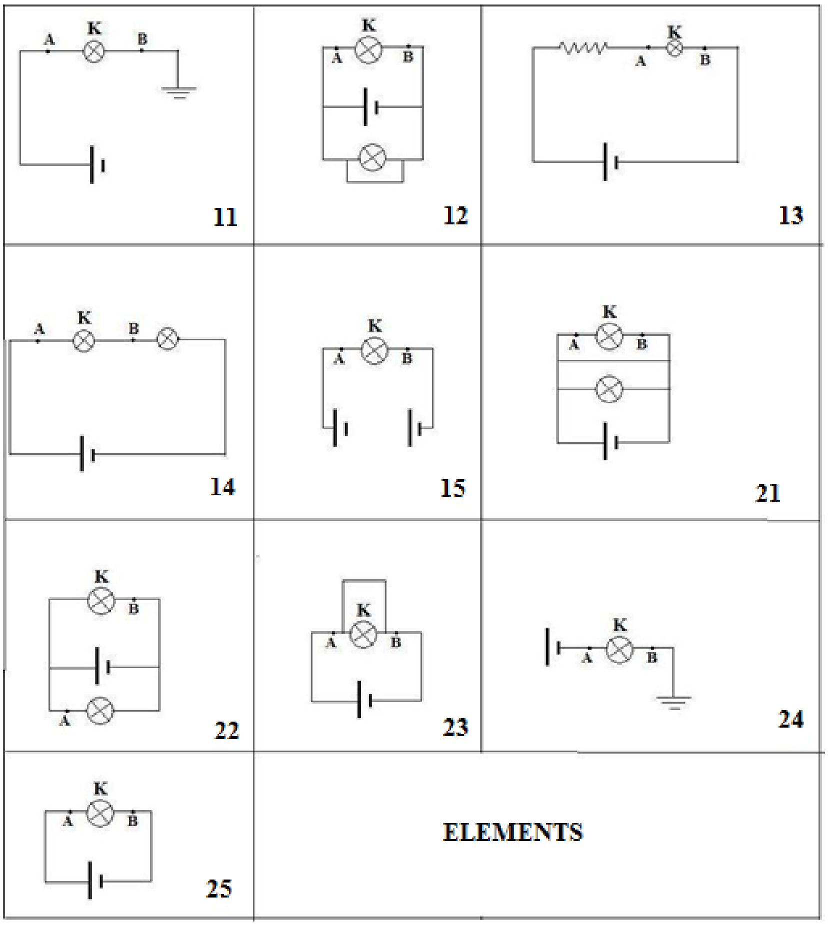

Table2. Constructs

1	11	12	13	14	15	21	22	23	24	25	5
Current flows through the circuit											Current does not flow through the circuit
Energy of the battery increases											Energy of the battery decreases
Current divides into branches											Current does not divide into branches
Current flows through point A											Current does not flow through point A
There is a potential difference between point A and B											There is no potential difference between point A and B
Bulb K lights											Bulb K does not light
Potential in point A is greater than point B											Potential in point A is smaller than point B
There is a potential difference between the poles of the battery											There is no potential difference between the poles of the battery
Current value through point A is greater than point B											Current value through point A is smaller than point B

The reason why the researcher chose the constructs is in order to focus on the concepts of circuit, potential difference and current.

PROCEDURE

The 10-element grid, prepared by the researcher was presented to the candidate teacher of physics, who was then asked to rate all the elements according to the constructs. All the elements were rated on a 5-point scale by the participant. For a pole of the construct, 1 stands for 'reflects fully'; 2 for 'to a great extent'; 3 for 'element is in the middle according to this construct, or indecisive'; 4 for 'reflects poorly'; 5 for 'not at all - contrast'. In this manner, each element was rated as terms of the obtained constructs until each construct was applied to the elements. The result of this procedure was a matrix that displays a construct in each row and has a 5-column section evaluated by a 5-point scale. An element, evaluated with 1 means that the construct strongly applies to this element, while 5 indicates that there is a strong, contrasting construct.

The participants' grid was qualitatively analyzed by the computer program GRIDSUITE.

FINDINGS

The grid compiled by the candidate teacher of physics is presented in Table 3. The data obtained from this grid are analyzed. The comments of the candidate teacher of physics about the elements are as follows:

- In Element 11, current occurs from the positive pole of the battery to earth. Thus, there is a potential difference between point A and B. Point A is at high potential. Current decreases at the resistor.
- In Element 12, electrical current splits into branches, whereas the current in the similar circuit in Element 21 does not split.

- In Element 13, potential difference and current are related, and direct current is produced. Potential of point A is greater than that of point B. Current decreases at the bulb.
- In Element 15, direct current occurs from high potential to low potential.
- In Element 21, the bulb does not light because of short circuit.
- In Element 22, current splits into branches. Potential of point A is greater than that of point B. Current decreases at the bulb.
- In Element 23, current flows, the bulb is not subject to short circuit. Potential of point A is greater than that of point B. The current that flows through point A is greater than the current that passes through point B.
- In Element 24, electrical current occurs from earth to the negative pole of the battery. The current that passes from point B is greater.
- In Element 25, potential of point A is greater than that of point B. Current decreases at the bulb.

The candidate teacher of physics made the same evaluation for Element 14 and 13, considering also that the bulb is a resistor. The participant stated that the current splits into branches in Element 12 and 21, however, she/he did not realize the short circuit in Element 21. Furthermore, the participant made an incorrect rating in element 15 because she/he thought that direct current would occur from high potential to low potential before the circuit is completed. The participant stated correctly the relationship between potential difference and current in Elements 13, 12 and 25. According to Elements 25, 22, 13 and 11, the participant thought that the current decreases at the bulb.

Table 3. Participants' Grid

1	11	12	13	14	15	21	22	23	24	25	5
Current flows through the circuit	1	1	1	1	1	1	1	1	1	1	Current does not flow through the circuit
Energy of the battery increases	5	5	5	5	5	5	5	5	5	5	Energy of the battery decreases
Current divides into branches	5	1	5	5	1	5	1	5	5	5	Current does not divide into branches
Current flows through point A	1	1	1	1	1	5	1	1	1	1	Current does not flow through point A
There is a potential difference between point A and B	1	1	1	1	1	5	1	1	1	1	There is no potential difference between point A and B
Bulb K lights	1	1	1	1	1	5	1	5	1	1	Bulb K does not light
Potential in point A is greater than point B	1	1	1	1	1	3	1	1	5	1	Potential in point A is smaller than point B
There is a potential difference between the poles of the battery	1	1	1	1	1	1	1	1	1	1	There is no potential difference between the poles of the battery
Current value through point A is greater than point B	1	1	1	1	1	3	1	1	5	1	Current value through point A is smaller than point B

By means of GridSuite4, the similarities between the elements and conducts were examined and presented in Table 4. The significant differences were evaluated by the researcher. The participant rated Elements 11, 13, 14 and 25, and Elements 12, 15 and 22 100% similarly. The participant made the 100% same evaluation for the conducts "Current passes through the circuit" and "Energy of the battery decreases", and likewise between the conducts "Current passes through point A" and "There is a potential difference between point A and B".

As a result, the students are aware of the fact that potential difference causes current. This is evident from the 100% match between the constructs “Current passes/does not pass from point A” and “There is (no) potential difference between point A and B”. Equally, the constructs “The energy of the battery increases/does not increase” and “Current passes/does not pass through the circuit” are 100% similar. This demonstrates that the students correctly construct the relationship of the energy of the battery with current. When the similarities among the elements are observed, it is seen that element 13 and element 25 are 100% similar. Hence, the students think that when the current passes through the bulb, it will light. Moreover, it is observed that the students have a misconception stating that the current will decrease once it passes through the resistor.

The participant rated correctly Elements 21 and 23 among the elements 12, 21and 23 about short circuit, which indicates that the participant is familiar with the concept of short circuit and is capable of interpreting. However, the participant could not notice the short circuit in Element 12. Moreover, the participant believed mistakenly that current would occur in the circuits 11, 15 and 21. This is because the participant knew that direct current would occur from high potential to low potential and felt into error that potential difference would occur.

Table4. Similarities between Constructs and Elements

Raw Data | Basic Statistics | Element Characteristics | Matrix similarities Elements | Matrix differences Elements | Matrix similarities Constructs | Matrix differences Constructs

Mean Centrality: 25

	Current flows th...	Energy of the ge...	Current divides ...	Current flows th...	There is potenti...	Bulb K lights/Bu...	Potential in poin...	There is potenti...	Current value t...
Current flows t...		-100	-40	80	80	60	70	100	70
Energy of the g...	100		40	-80	-80	-60	-70	-100	-70
Current divide...	40	-40		-20	-20	0	-10	-40	-10
Current flows t...	-80	80	20		100	80	70	80	70
There is potenti...	-80	80	20	-100		80	70	80	70
Bulb K lights/B...	-60	60	0	-80	-80		50	60	50
Potential in poi...	-70	70	10	-70	-70	-50		70	100
There is potenti...	-100	100	40	-80	-80	-60	-70		70
Current value t...	-70	70	10	-70	-70	-50	-80	-70	
Centrality	40	-65	-12	48	48	40	44	40	44

Raw Data | Basic Statistics | Element Characteristics | Matrix similarities Elements | Matrix differences Elements | Matrix similarities Constructs | Matrix differences Constructs

Mean Centrality: 81

	11	12	13	14	15	21	22	23	24	25
11		89	100	100	89	56	89	89	78	100
12			89	89	100	44	100	78	67	89
13				100	89	56	89	89	78	100
14					89	56	89	89	78	100
15						44	100	78	67	89
21							44	67	56	56
22								78	67	89
23									67	89
24										78
25										
Centrality	88	83	88	88	83	53	83	80	71	88

RESULTS AND DISCUSSIONS

This study sought to reveal the usability of the RGT in DC electrical circuits and the concept image of the participant, concerning the subject. It was found out that detailed information about short circuit, potential difference and current could be obtained by investigating the prepared grid. It was seen that the students did not use numbers other than 1-3-5 in the grid rated from 1 to 5. This could be interpreted as an indicator of the certainty of the students about their ideas on the concepts. A misconception, which states that the current would decrease once it passed the resistor, was found out among the participants. The studies by Pardhon and Bano (2001), Küçüközer (2003), and Çıldır and Şen (2006) also state a similar misconception among students. It was observed that the Repertory Grid Technique is practical to reveal the misconceptions.

It was observed that the participant knew that direct electrical current would occur from high potential to low potential, nevertheless, she/he did not know how potential difference is produced in batteries. Although the participant is theoretically knowledgeable about the issue, his/her practical comments were incorrect.

Students' acquisition of knowledge is a common objective of science teachers. As emphasized by Fetherstonhaugh (1994), and Winer and Abend (1995), the RGT may provide science teachers with a valuable source of information. In science education, the RGT has been widely recommended and used in a variety of ways to observe the change in students' understanding of concepts over time, and to assess the knowledge of the learner. We suggest that the Repertory Grid Technique be used in assessing declarative and procedural knowledge in science education.

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THE IMPLICATIONS OF USING UBUNTU AS A GUIDING PRINCIPLE FOR RESEARCH IN RURAL CONTEXTS

Constance Khupe

University of the Witwatersrand, Johannesburg

Constance.khupe@wits.ac.za

Ann Cameron

University of the Witwatersrand, Johannesburg

Ann.cameron@wits.ac.za

Moyra Keane

University of the Witwatersrand, Johannesburg

Moyra.keane@wits.ac.za

ABSTRACT

Research that claims to be participative and that aims for redress needs to be inclusive from the framing of paradigms through to the research products. When carrying out research in rural contexts, conceptualising research questions, decisions on data collection methods, the choice of instruments, data analysis, and ethics, the ownership and dissemination of findings, have to be made in a way that fits with the worldview and life context of participants. In South Africa, research grounded in Ubuntu can be one way of ensuring consonance with the participants' worldview. In this framework, research quality is largely dependent on the researcher's willingness to establish authentic relationships with participants, and to recognise community structures, knowledge and values. Ubuntu, as an African philosophy, is relevant and meaningful to rural South African participants (Venter, 2004), and is therefore likely to result in meaningful science education research. We have learnt that we may not enter a community from a perspective of 'superiority', or even 'objectivity', but need to indicate our willingness to co-learn with participants throughout the research process. In this paper we discuss how ubuntu can support and underpin rural research – as well as extend the boundaries of conventional research design. We consider the implications of using ubuntu as a guiding principle in research in rural communities, drawing on experiences from the early part of our engagement with the participating community. This paper's contribution lies in opening dialogue on approaches to science education research in rural contexts.

Keywords: *ubuntu; rural education; participative research*

INTRODUCTION

This doctoral research into Indigenous Knowledge (IK), ubuntu and the science curriculum seeks to discover science-related community knowledge and practices which could be used in classroom learning. This aim aligns with the principles of the South African National Curriculum Statement, which requires the inclusion of IK into school subjects. We work with high school students in a rural community in KwaZulu-Natal, South Africa. Elders in the community pass on IK to the youth. It is this resource of wisdom and knowledge, particularly relating to natural phenomena and ways of living in nature, that we explore with the community. As outsiders we can serve a bridging and facilitating function that will possibly allow the recognition and inclusion of this knowledge into the classroom. We draw on the principles of ubuntu throughout the research to make decisions on ethics, time frames, data collection, data analysis, as well as dissemination of findings. Our research uses a participatory approach, concurring with (Bernstein, 1983), that research paradigms reflect our beliefs about the world. This paper reports on the methodological implications of using ubuntu as a framework and describes instances to support a model of participatory-ubuntu research in a rural setting in South Africa.

WHAT IS UBUNTU?

There is no single definition of ubuntu and it is difficult to define the concept accurately (Mnyaka & Motlhabi, 2005). Bishop Desmond Tutu, the Chairperson of South Africa's Truth and Reconciliation Commission (TRC) had this to say about ubuntu:

> Ubuntu is very difficult to render into a Western language. It speaks of the very essence of being human…It is to say "My humanity is caught up, is inextricably bound up in yours". We belong in a bundle of life (Swanson, 2007:58).

The term ubuntu is as old as many African languages, but has only more recently entered academic discourse. Ubuntu is the Zulu version of 'botho' (Sotho/Tswana), 'unhu' (Shona), 'bunhu' (Kalanga and Tsonga), 'umuthu' (Malawi), 'umundu' (Yawo), and 'vhutu' (Venda). It means: 'being human' or 'humanness' (Mdluli, 1987). It is a philosophy that not only promotes the common good of society (Venter, 2004) but is also a way of conceiving reality. There is controversy on whether ubuntu is uniquely African, or can be found in other parts of the world. Kamwangamalu (1999) makes reference to historical events such as slavery, colonialism, apartheid, and Nazism to dispute the existence of ubuntu virtues is Western societies. Gaylard (2004) and Louw (2004) however report the existence of ubuntu-related values in both Western and Eurasian philosophies respectively. It is our opinion that ubuntu is a feature of traditional societies, which has persistently faced erosion from modernisation (which often carries with it secularization, rapid urbanisation, individualism and materialism). As Venter (2004:149) puts it, "ubuntu is an ideal concept, often flawed in interpretation and practice". Like other indigenous values, ubuntu is under threat, hence the call in both academic and political circles for its revival.

The principles of ubuntu are part of the fabric of rural communities (notwithstanding the fraying of the fabric at times) and are recognized as contributing to community wisdom and survival. These principles include: respect, communalism, interdependence, supportiveness, solidarity, cooperation, caring for others, and participation for the common good (Hamminga, 2005; Keane, 2007; Malcolm & Alant, 2004; Olinger, Britz, & Olivier, 2007; Tambulasi & Kayuni, 2005; Venter, 2004). Ubuntu is the basis of the African worldview. Ubuntu affirms the humanity of the individual in direct relation with fellow humans, and it carries positive connotations of fostering and manifesting qualities of kindness and neighbourly support (Louw, 2004). The South African Welfare Department defines ubuntu as a principle for caring for each other's well-being, where each individual's humanity is expressed through his/her relationship with others (Department of Welfare, 1997 in Tambulasi and Kayuni, 2005). A person can therefore be commended as '*having* ubuntu' or negatively described as '*without* ubuntu'.

Ubuntu is valued in indigenous communities, where relationships are at the centre of worldview. It is clearly expressed in the Zulu/Xhosa maxim, *umuntu ngumuntu ngabantu* (i.e. a person is a person through other persons). Expressed thus, ubuntu can be interpreted as a rule of conduct or social ethic (Louw, 2004). Ubuntu is often described as the foundation of all African societies (Mdluli, 1987) and as the basis of African communal life (Tambulasi and Kayuni, 2005). It contributes to the sustenance and well-being of a people (Venter, 2004).

For the purposes of our research in general and this paper in particular, we use two definitions from Kamwangamalu (1999).

> …ubuntu is understood as a collective solidarity whereby self is perceived primarily in relation to the perception of others, that is, persons are perceived less as independent of one another, and more as interdependent of one another (Laden, 1997 in Kamwangamalu (1999:26).
>
> Ubuntu is about how you relate to people and is …a fountain from which actions and attitudes flow (Dandala, 1996 in Kamwangamalu, 1999:26-27).

Ubuntu is not just about human acts, but about being. It is a disposition and an orientation that seeks to contribute towards the well-being of others (Mnyaka & Motlhabi (2005). Through ubuntu, the individual becomes conscious of his/her being, privileges, and responsibilities towards self and others, and is able to say, "I am, because we are; and since we are, therefore I am" (Mbiti, 1969).

UBUNTU AND RESEARCH

The use of ubuntu in research is a relatively recent phenomenon but is gaining ground in educational studies in South Africa. Its use comes from the growing need for research oriented towards social justice, research that gives space to the democratic, egalitarian and ethical engagement of participants (Swanson, 2007). In the rural South African context, the framework of ubuntu is consonant with the worldview of research participants (Malcolm & Alant, 2004). Ubuntu aligns with paradigms that acknowledge rural research participants' perspectives and interpretations, even though not necessarily satisfying universal 'truths' (Muwanga-Zake, 2009). Swanson (2007) used ubuntu as a guiding principle for fieldwork based in qualitative research methodology. Keane (2005) used ubuntu to explore a South African rural community's understanding of relevant science and Muwanga-Zake (2009) used ubuntu as a philosophy and methodology in evaluating a computer educational programme. Because people are not born with ubuntu, but acquire the communally acceptable and desirable ethical standards throughout life, it would be of valuable for education and education research to make use of this framework (Venter, 2004). Our decision to use ubuntu as a guiding principle results from an understanding that it would not be appropriate to research into Indigenous Knowledge using methodologies that do not give room for interaction at a more personal level.

The use of ubuntu especially in a participative approach leads to sensitivity to participants' perspectives and affords multiple insights (Swanson, 2007). It gives room for respectful relationships and cross-cultural understanding between the research partners. Through its emphasis on responsibilities and obligations towards collective well-being, the use of ubuntu helps to break the 'I-You' dichotomy of traditional research (Swanson, 2007). It gives research a human face as it respects participants' values, norms and needs and emphasizes collaboration. The use of ubuntu has the potential to improve the validity, relevance and usefulness of the research outcomes by bringing the partners closer in purpose. Ubuntu is thus an empowering process (Muwanga-Zake, 2009). Venter (2004) recommends that education in Africa needs to pay attention to interpersonal and cooperative skills, and we suggest the same for research. In using ubuntu we note Minkler's (2004:687) advice that "…the quality of findings…is directly and immeasurably affected by the actions when beginning and maintaining a working relationship professionals and citizens".

IMPLICATIONS OF USING UBUNTU: OUR EXPERIENCE

One clear requirement of this approach is flexibility and lengthy engagement. We recount here a story of the initial stages of the research. From the beginning, the implications and consequences of being grounded in a framework of ubuntu are far-reaching and at times challenging. Our partnership is now six months long, and we have used the time to foster relationships and to co-design the research with the community. The community participating team comprises thirty 11th Grade Physical Sciences and Life Sciences students, a community youth leader who is also a research assistant, two teachers and six community elders.

In our first visit to the site we had planned to discuss with the school and local authorities, the participating non-government organization, the elders and the students our idea to explore indigenous knowledge within the community. We hoped to comply with University ethics requirements by immediately issuing information sheets, consent forms, as well as questionnaires through which we wanted to collect data on students' prior knowledge, (all carefully translated into isiZulu). We held a meeting with representatives of local and provincial government departments. The robust discussion we had with them gave us the opportunity for self-reflection. Questions on issues such as how the community would benefit and how they would feel a sense of ownership of the project were raised. How would we provide for sustainability? What would we do about the raised expectations? Could we guarantee prolonged engagement? We realized that the production of knowledge for its own sake is not a priority for a community faced with pressing needs of employment, food security and health. We realized we had to balance academic requirements with a consideration of community needs so that the process as well as product of the research is immediately beneficial to both sides. It also needed to leave a knowledge legacy and not simply to terminate with a thesis outcome. Discussions with representatives of the traditional council also showed we are not supposed to impose our timeframes on the participants, but respect their commitments outside our engagement with them. This experience showed us that our plan, though in principle committed to ubuntu, needed to be flexible and provide for extensive changes based on the field experience of interacting with participants for it to be really grounded in ubuntu.

After this practical learning on our part, we understood that we should only give verbal explanations of our university ethics requirements at this stage, and left the potential participants to think about and further discuss the project. We realized that the signing of forms could only happen at a later visit. We had no right to propose contractual relationships. Rather, we formed relationships with a group of youth who wished to be involved. The youth leader was to be our main community research assistant on the understanding that fixed remuneration was not possible but that as funding may allow we could contribute a stipend on an ad hoc basis. In participative research the balances between power, partnerships and purposes are complex. Through an understanding of ubuntu it became easier to establish a collective intention that 'we are in this together'. We now had a community intention rather than a researcher-participant contract.

We are also aware of the importance of language in this context. We are not first language Zulu speakers but we have and will continue to try as far as possible to communicate in isiZulu. In situations where we think we may not be able to accurately communicate in the local language, we will seek help from our research assistant. In our communication with the students, we also are aware of their difficulties with English, so we encourage them to speak in isiZulu if this makes them feel more comfortable. We are also aware that there might be some among the elderly participants who may not be able to read and write, so we requested our research assistant to assist where necessary. As far as possible we liaise with the research assistant, the participating teacher and the Secretary of the Traditional Council, on the relationship hierarchies and dynamics of the community so that we may also try to fit in. We continue to seek ways of developing a deeper understanding of the participating community and to also create opportunities for them to participate in our contexts. We arranged a lunch outing with key leaders in the broad community where the research agenda was not the focus. We also co-hosted the community researcher in Johannesburg. These are examples of going beyond the research plan to creating an authentic expression of ubuntu in practice.

Using ubuntu sometimes implies listening to issues that may not be directly related to the research. The participants listen to our needs and our agenda, and in a situation of mutual respect and understanding, we also listen to their concerns. This involves continuous decision making on ethics issues throughout the research process. We get privileged access to inside information, which our ubuntu principles do not allow us to disclose. We view having a participant share that kind of information with 'outsiders' as evidence of the growing trust with the individual and the community they represent. Such conversations are also an opportunity for continuous feedback on both individual and community needs. As a result we look to the engagement with the community with optimism.

Using ubuntu requires a commitment on the part of the researcher to keep promises, so that participants also see their commitment as binding. Our student participants requested that we should play the video recordings on our discussions on their prior knowledge. In our next visit we will play them the video clip. This is part of information sharing. Being able to watch and listen to their own voices is an important contribution to empowerment for most of these students. Playing the videos may even encourage some of the students to contribute in coming discussions, and may also be used as member checking on opinions previously expressed. It is possible that playing of the video clip to students may form a basis for new discussions. In a similar way we make sure that any photographs are duplicated for community members.

In our engagement with the community we are conscious of the need to ensure participants are meaningfully engaged. Consequently, we managed to have one of the participant teachers attend a conference on research in science and mathematics education, which she described as a great learning opportunity for her. Whenever we have opportunity we are keen to have the community directly benefit. We plan to share the research findings with participants in the form of a community exhibition centre for the knowledge found in the research. A summary of the findings authored by all participants will also be presented in a booklet in both English and isiZulu. These sometimes uncalculated turns and unfoldings of lived engagement present challenges for a PhD student within the academy and also for funders who expect a more rigid and template-constrained plan.

In a prolonged engagement such as in our research, we keep in mind the need to continue in conversation with the community, making decisions together with them on data collection, data interpretation as well as decisions on how to use the data for the benefit of the community. We view the research as a continuous learning process for all partners.

CONCLUSION

Our experience in the field so far has shown that the use of ubuntu presents both benefits and challenges. We have learnt the importance of continuous dialogue and the need to develop trust amongst all research partners. We all believe the research process has potential to contribute to local level decisions on curriculum design and development in a way that recognises local knowledge and potential. By aligning the research process to the aspired outcomes, participative engagement both contributes to more authentic knowledge and to the benefit of all participants.

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CURRICULAR ISSUE OF FORMATIVE ASSESSMENT IN SLOVENE PRIMARY SCHOOLS

Natalija Komljanc

The National Educational Institute

1000 Ljubljana, Poljanska 28, Slovenia

natalija.komljanc@zrss.si

ABSTRACT

This text presents the secondary analysis of the applicative results development of the Institute's project in the years from 2006 to 2009, in which 34 Slovene primary schools participated actively. The new didactic approaches demand teacher's flexibility according to the class subject they teach. Formative accompaniment in the evaluation process, which includes the teacher's feedback about the value of student's knowledge, is one of the basic didactical approaches for introducing the transformative pedagogy to Slovene schools. This approach derives from constructivist principle emphasizing classes that are student oriented in order to encourage student's learning style. By using the formative assessment, the teacher encourages students to produce autonomous, critical, and creative thinking and to act independently when choosing ones own learning style and interesting learning contents. Moreover, it encourages him/her to look for the solutions to the problems that may occur at any class subject. Along with the paradigmatic school transformation from mechanical or transmission schools into holistic or transformational, the formative assessment differs in main elements from the traditional assessment. The formative assessment does not permit the students to be fully engaged without the parent's or teacher's help in realizing their individual curriculum, which is accordant with the compulsory national curriculum. This text will show how the individual and social cooperation level can intertwine between the educational participants.

Keywords*: formative assessment, curriculum, teachers' training, knowledge, transformative learning.*

INTRODUCTION

Formative assessment is becoming one of the moving forces of the learning process. In this way, Vygotsky’s theory of proximal development and cooperative learning between teacher, student and schoolmates is confirmed (Vygotsky, 1977 in Komljanc, 2004).

Formative assessment is becoming a focus in the professional development of teachers, and also a focus in policy documents on educational assessment (Bell, Cowie, 2001).

In the national project development, it was affirmed that the effective feedback is the key element of pedagogic communication within the learning process and/or self-development. The qualitative measuring of learning can essentially contribute to a better learning motivation, to longer schooling and consequently to higher professional education of our citizens (Komljanc, 2010). These theses enable to look more carefully on the benefits of formative assessment for learning and on science.

This article includes some descriptions of facilitating formative assessment from "bottom up" approach. There are also some characteristics of formative assessment, some definitions and references for more efficient formative assessment in science education.

SOME CHARACTERISTICS OF FORMATIVE ASSESSMENT

Formative assessments have evolved as a means to adapt to students' needs. As opposed to a summative assessments designed to make judgments about students' performance and produce grades, the role of the formative assessment is to improve learning. Benchmark tests are used to predict students' performance on other tests (most often state assessments) whereas the formative assessment tests are intimately connected to instructions.

Since, in this phase, a teacher redirects from the content or discipline focused education to the consideration of students' needs, it signifies that the teacher should be capable to deal with the procedures. Moreover, at the same time (s)he should play a role of an emphatic wise man, who helps students not only to perceive, comprehend but also to test, examine, strengthen and interpret solutions or procedure and to provide sensible procedure positioning in the system.

The formative assessment theory derives from the critic of weaknesses of the existing education and assessment, which were behaviourist oriented, program centred, curricular focused, mechanic and uniformed and whose goal was repetitive knowledge (Komljanc, 2008). At the same time, the formative assessment corresponds to the modern education needs for achieving mutual communication, cooperation between partners, process oriented knowledge and transformative learning.

Formative assessment has a long history. Historically, formative assessments were of instructional units and diagnostic assessments were used for the placement purposes. Formative assessments are a part of instruction designed to provide crucial feedback for teachers and students. Assessment results inform the teacher about what has been taught well and what not so well. They inform students about what they have learned well and what they have not learned so well.

Feedback in formative assessment most drastically interferes in learning instructions. The latter are not only the described steps for single-meaning and unconditional imitation of the function (operation) that has already been excellently performed several times but person-oriented recommendations including not only regulations but also principles for qualitative pro-active existence and successful solving of conceptual plans or well-received innovations and sensible innovation procedures.

The group research has shown that the formative assessment, which is student oriented, raises the knowledge level and generally improves the quality of education because it minds what a student has to say, which influences on the learning process. Therefore, teachers are advised to replace the simple passing of subject contents and "closed" teaching style, which limits communication possibilities, by interactive style, for which they take enough time so they can think about students' reactions and leave students enough time to display these reactions. The most common mistake teachers make, is that they do not give enough time to students to provide answers and instead teachers answer by themselves as they are more interested in the value of content transmission and not in students' comprehension. Teachers' interest in a child leads him/her toward listening student's reflections on the content and determining his/her comprehension. Feedback in that sense is more frequently content oriented and rarely methodologically oriented (Komljanc, 2004).

"Competing, who will be the first to raise the hand and shoot the correct answer, is meaningless. Even the incorrect answer or "*I don't know*" answer can be a good starting point for student's and teacher's reflections. In the contemporary, dynamic world, frequently not only one correct answer is possible" (Black, 2009). According to Black, the right learning method upgrades ideas that students already have. That is why teachers should give up the role of a fact presenter and explainer and adapt the role of a research promoter. At Kong's College in London, the research on the impacts of classic assessment showed that it stimulates only superficial knowledge and does not consider students' needs because there is too much emphasis on the quantity and not as much on the content and quality of knowledge. "Children compete instead of focus on learning" (Black, 2009). Formative assessment, which is constructivist and not behaviourist oriented, encourages learners to learn and teachers to focus on a student and not only directly on the subject discipline.

Teachers should be interested in students' thinking abilities that are why they have to put more effort in forming "right" questions instead of searching for the "right" answers. Likewise, they should be aware of the fact that there is no evidence proving that a frequent examination raises the knowledge level. On the contrary, examinations often unnecessarily burden teachers and students. According to Black and Wiliam (1998), using only summative assessment has the negative impacts on learning. Which arguments do they use? We are dealing with school-based formative assessment. Everybody should be allowed to show their best qualities and respect their good deeds. We are becoming mature by considering also other viewpoints. Even the incorrect answer or the "I don't know" answer may be a good starting point for creative thinking. Teachers should take time to reflect on students' reactions.

In the past, schools were mainly interested in transmitting knowledge from generation to generation as faithfully as possible. The school of the 21st century is no longer oriented toward imitating but it encourages all education factors to discover (invention) and to update usefully and concretely (innovating). The classic knowledge assessment is not sufficient even for the so-called corrective purpose, not to mention achieving the goal of encouraging creative thinking and concrete realization of ideas and presenting as well as interpreting findings. Constructivist formative assessment takes into consideration all basic learning forms, which is the most humane and cognitive beside the social constructivism. Creators avoid behaviourist methods, which they use mainly for assuring accuracy when defining the basic notions for comparing and constructing new compositions.

Some definitions of formative assessment

Over the last decade and even more, there has been a major interest in a number of countries on the assessment for learning or formative assessment. One of the driving forces for this has been work of Black and Wiliam (1998) from the Assessment Reform Group in London.

Hargreaves (2005) argues that there are various conceptions of assessment for learning such as: monitoring students' performance against targets or objectives, using assessment to inform next steps in teaching and learning, giving feedback for improving students' knowledge, some kind of control or turning assessment into a learning event.

Bell and Cowie (2001, p. 552) put out in their article titled The Characteristics of Formative Assessment in Science Education nine characteristics of formative assessment that were identified by the teachers. The characteristics are:

1. responsiveness;

2. sources of evidences,

3. tactic process,

4. usage of professional knowledge and experiences,

5. an integral part of teaching and learning;

6. formative assessment is performed by both teachers and students;

7. purpose for formative assessment;

8. contextualized nature of the process; and

9. dilemmas.

Slovene teachers have the same response when they were asked about formative assessment in the process of action research. The teachers and students as well as their parents and school leaders supported the formative assessment even more after the development-applicative project.

Formative assessment is described in the policy document as: … "the integral part of teaching and learning process". It is used to provide the student with feedback, to enhance learning and to help the teacher understand student's learning. It helps to build an image of a student's progress, and informs about the next steps in teaching and learning (Ministry of Education, 1994, p.8 in Bell, Cowie, 2001, p. 538).

Along with the formative assessment development, the project group in Slovenia came up with three definitions of formative assessment regarding the development of participants' abilities to implement changes in the school-based evaluation (Komljanc, 2009):

1. Formative assessment is a form of prior knowledge development on higher levels (Komljanc, 2007);

2. Formative assessment is a form of mental development – ability to comprehend, judge and behave (Komljanc, 2008);

3. Formative assessment is a feedback for better knowledge (Komljanc, 2009).

In the initial phase of innovative evaluation, performers dedicated their attention mostly to diagnostics and forms of pedagogic communication for attaining higher knowledge levels. The cognitions on the motivation quality have impact on the development of definition in the sense of developing the teaching quality in order to offer the possibilities to comprehend and not only to receive information regarding the prior knowledge. All together gradually brought teachers to the conditions required for the implementation of process oriented education. To achieve this, most teachers spent at least three years intensively working on their methods, actively following counselling on how to develop one's own practice, pedagogic communication, how to cooperate and motivate students, who are an essential element in learning process.

The new communicative didactic approaches demand teacher's flexibility in the teaching process, especially in diagnosing the student's prior knowledge, creating education strategies and evaluating achievements. Formative assessment of the learning and teaching development, which includes the teacher's feedback on student's knowledge value and student's information on teaching value, is one of the basic didactic principles for the implementation of transformative pedagogy in Slovenia. The formative assessment originates from the constructivist principle of the student oriented learning process for the development of learning style of an individual student within a social learning group. By introducing formative assessment, a teacher accustoms each student to an autonomous, critical and creative thinking, as well as to the self-initiative choice of student's own learning style and interesting contents. Moreover, it encourages a student to find solutions to the problems at every school subject.

The constructivist formative assessment stimulates cooperation and efficient dialogue between learners. With the adult's help (parents, teachers and other experts), children develop self-regulative pattern when choosing their learning style. Thus, the self-regulation is the base for implementing transformation. At the formative evaluation, student cannot be entirely engaged without the parents' and teachers' help in crating individual curriculum, which is consistent with the compulsory national curriculum. The school is actually optimal only when it enables student's personal development which, in a certain development phase and environment, (s)he could not attain without the help of adults. This is in fact the point of schooling.

Progress is the main aim of the definitions of assessment knowledge in Slovenia and in New Zealand. This aim can be suitable also for science teachers and students. The definition of the formative assessment recognizes the benefits in the process of students' learning and teachers' support (Cowie, Bell, 1996 in Bell Cowie, 2001).

Some other definitions of formative assessment underline some important didactical component such as:

1. formative assessment is a dynamic process,
2. formative assessment is a form to help students in his or her learning process,
3. formative assessment is a continuative services of instructions,
4. formative assessment is a form of accompaniment,
5. formative assessment is improving the didactical dialogue between learners and teachers and also parents,
6. formative assessment is a form of arranging learning data for future planning of learning and teaching,
7. formative assessment is an approach for selecting learning aims,
8. formative assessment is a strategy for regulating education process,
9. formative assessment is an archive of achievements…(Komljanc, 2004).

Some benefits of formative assessment for assessing science knowledge

In New Zealand and also in Slovenia, we have had different didactic approaches for better measurement in education, but all of them were very much oriented on continuous summative assessment. The most popular feedback has been grades and external examinations.

The response to these criticisms can be summarized as a need to assess a wider range of science learning outcome, such as performance of investigation skills (Johnson, 1989 in Bell, Cowie, 2001, p. 537) and multiple forms of thinking (Gardner, 1985 in Bell, Cowie, 2001, p. 537). There are also proposals for using wider range of assessment tasks or instruments and performance-based assessment. Assessment knowledge must be integrated with the curriculum and assessed in a more open, humanistic and constructivist way.

Slovenian teachers who were supported by advisers in project of the National Education Institute were using a guiding instrument with the focus on the diagnoses of the prior knowledge, awareness of teaching aims and learning outcomes and also on process of learning and teaching and consequently on students' learning style. In the process, the instrument enables teachers to reach the optimal achievements of each student in the learning group.

Not just in Slovene and in New Zealand but also in other countries like UK, Australia, Singapore, Hong Kong teachers are aware of the difference between formative and summative assessment knowledge (Komljanc, 2009).

Students can benefit from formative assessment in the following ways:

1. developing divergent thinking,
2. using reflection as a sort of analysis,
3. opportunities for searching different methods of observing and interpreting data,
4. planning the process of learning and teaching at the same time,
5. constructing various research questions,
6. orientation on process for developing prior knowledge,
7. integrating different content more often,
8. using different sources,
9. developing not just actual but also reference knowledge,
10. more autonomous study with orientation on self-regulation,
11. discovery approach, with defining the hypotheses,
12. experiences and theoretical knowledge use.

When teachers start with formative assessment, they ask for help by asking question like "How to start reforming the assessment system?" In Slovenia, The National Education Institute helps them by offering three principles instead of classical roles and five recommendations for reconstructing an innovative school measurement system. They accept also two indicators, which are briefly presented further on:

Three principles of knowledge assessment, which were very well accepted, are (Komljanc, 2008):

1. "Assessing strong and weak knowledge."

This principle was not so often used at the beginning. Only 3% of the project members use diagnostic approach, but after working in project team during three years, 98% teachers accept prior knowledge in planning the system.

2. “Assuring contact between learning levels”.
   Nobody was oriented on personal learning. Almost all used the classical teaching style. After a three-year usage of the instrument for formative assessment, 76% of teachers replaced the old teaching style with a more personalized teaching approach.

3. “Assuring actual feedback on the knowledge development.”
   At the starting point, 17% of teachers knew how important useful feedback was, but at the end of the project, 96% of teachers confirmed, that they are very much oriented on the effective positive feedback in the learning process, which means that the teacher and the student have improved their learning and teaching.

All three principles can be also useful for students and teachers in science matter.

Teachers found help in the suggestions or recommendation for realizing principles. Such as (Komljanc, 2010):

1. Exchanging information between the education factors for balancing needs and abilities and curriculum requirements
2. Counselling on how to eliminate weaknesses in prior knowledge – learning on higher level
3. Directing learning process for (co) influencing of factors
4. Control mechanism in the form of feedback for balanced learning and teaching
5. Summative assessment on the basis of complete information collection on student’s prior knowledge and improvement which is compared with reference measurement (the expected outcome)

For teachers, especially the first and the fourth recommendations are beneficial, as well as the last one. The biggest improvement was achieved with the first principle (7% at the beginning, 68% in the middle of the project, and 95% in the end). We can recognize that the Slovenian teachers improved formative assessment knowledge with better dialogue between teachers and students. Now, a more beneficial feedback is used in the learning process (7% at the beginning, 68% in the middle of the project, and 95% in the end). Therefore, we could conclude that the summative assessment is also more valid and reliable (14% at the beginning, 25% in the middle, and 78% in the end). Reliability in a sense of repeating the same response and validity in the sense of how good or correct the comparison between actual and reference level of knowledge was. There are still some possibilities for improving teaching methods and style. Teachers should more often give the needed personal instructions (29% at the beginning of the project, 78% in the middle, and 73% in the end). They should be also more oriented on the so-called sensible learning and on learning measurements or reference level of knowledge (14% at the beginning of the project, 25% at the middle, and 78% in the end).

In order for the teachers to perceive successful reactions in the upgrading of evaluation system, we have created two indicators. The first one pointed out the successful implementation of a lesson and the second signalized that the student has a greater knowledge than before (Komljanc, 2008). Both indicators directed the teacher and the student toward the qualitative inner control of learning and outcomes.

These indicators are very similar to the third trend of formative assessment, which is to match the views of learning, recognizing that each learner has to construct an understanding for her - or himself, using both incoming stimuli and existing knowledge, and not merely absorbing transmitted knowledge (Berlak, 1992; Gipps, 1994 in Bell, Cowie, 2001, p. 538). Central part of this teaching is the dialogue with students to clarify their existing ideas and to help them construct the scientifically accepted ideas which is very important for science teaching (Scott, 1999 in Bell, Cowie, 2001, p. 538). Formative assessment is a crucial component in teaching science and also others subjects with which agrees also Bell (Bell, 1995 in Bell and Cowie, 2001). The essential part of formative assessment is feedback or a dialogue because it can modify a learning effectiveness. It is also important that the feedback provide a generalization of the data, which can be also very useful in science teaching. In that way, students have the opportunities for rethinking and because of that they may have a dipper understanding of the scientific learning problem. Learning, teaching and assessment interconnected with feedback. The process of teaching is never done without the student's involvement. Their reflections are part of research work and also a part of the interpretation of their recognitions. As Gitomer &Duschl, 1995, p. 307 in Bell Cowie, 2001 said, the assessment is a continuous process that facilitates instructional decision making in the classroom.

CONCLUSION

The compilation between Slovene and New Zealand experiences in classrooms shows that the formative assessment is increasingly becoming a focus in the professional development of teachers and also headmasters. It is more supported by policy documents on educational assessment. The National Educational Institute has a web site with recommendations. There are three booklets in the last three years. The seminars are also supported by government and they are very well accepted by teachers. The National Education Institute has established a net for compulsory schools with continuous support for the teachers, engaged in the project, in developing formative assessment knowledge in practice.

The most beneficial is the purpose to change from standard to multiple purposes and because of that teacher with students develops different measures. Different measures can help also in raising standards in science field.

If we have an opportunity to compare and at the same time to improve standards with expected outcomes then we have also an opportunity to develop standards of knowledge in some culture areas. At the same time, we can also improve personal learning aims of each student. In this way, we actualize the actual and reference level of knowledge.

From policy point of view, the constructivist formative assessment "improving learning, reporting progress, providing summative information and improving programs" was recognised also in New Zealand (Bell, Cowie, 2001, p. 538).

Both, formative and summative assessment influenced on learning, but in different ways. While the formative assessment improves learning by fulfilling the learning gaps and correct misunderstanding, the summative assessment gives an external force for improving student's knowledge, but more or less without accurate instructions. From the research perspective, the formative assessment is more valuable for developing knowledge based on research questions. Because of the past experiences in summative assessment, we should do more research on formative assessment knowledge to recognise the benefits.

Our evaluation system does not follow the example of formative system in other countries as much as it should. Other countries actually achieve good results at the international knowledge measurements. Besides, contemporary tendency is suggesting more profound work with students and the development of more complex knowledge. Countries which support formative assessment emphasis the role of internal evaluation and prior knowledge developed control and therefore assessment for learning more. Thus, teachers' trainings are focused on searching for evidences of learning and on different forms of learning encouragement.

Formative assessment does not suppose that a grade should only be the teacher's matter in order to inform a student about it. It is formed by a mutual dialogue, which presumes that a student self-evaluates first. Teacher communicates well with students to improve the quality of education. This could be achieved by developing his/her personal abilities to engage more perception channels, multi-presentation, multi-dimensional thinking and focus on students' personal growth as well as by assessing multiple forms of knowledge, which is not only objective but also subjective. We should mind what to include in communication and what to exclude from it, and what to take into consideration and what not, we should consider as well the well-being. The form of communication indicates whether a teacher is interested mainly in student's permanent knowledge resulting in fundamental changes in student's personality or only in superficial and short-term knowledge. Likewise, it can be observed whether a teacher acts as student's partner, assistant, in short, whether (s) he performs all four teaching types according to Delors.

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FORMAL NUTRITION EDUCATION AND NUTRITION KNOWLEDGE OF 6TH GRADERS IN NINE-YEAR PRIMARY SCHOOLS IN SLOVENIA

Stojan Kostanjevec

University of Ljubljana, Faculty of Education

stojan.kostanjevec@pef.uni-lj.si

Janez Jerman

University of Ljubljana, Faculty of Education

janez.jerman@pef.uni-lj.si

Verena Koch

University of Ljubljana, Faculty of Education

verena.koch@pef.uni-lj.si

ABSTRACT

Our research focused on the analysis of the impacts of the formal nutrition education on the nutrition knowledge of the 6th graders of nine-year primary school pupils, as well as the role of home economics as a school subject. The purpose of the research was to determine the level of nutrition knowledge of the pupils at the beginning and at the end of the school year. The research study involved 28 home economics teachers and 630 6th graders of nine-year primary schools in Slovenia who attended home economics classes in 2006/2007 and received formal education on nutrition. The pupils' nutrition knowledge was assessed by a written test given at the beginning and at the end of the course on nutrition. The results of the research showed that nutrition education has effects on the pupils' knowledge. However, no statistically significant differences in the knowledge between boys and girls were found and nutritional education did not significantly influence the dietary habits of the pupils.

Keywords: *nutrition education, nutrition knowledge, pupils, dietary habits.*

INTRODUCTION

Nutrition education, which takes various forms of formal and informal education, can significantly change nutrition behaviour and change dietary habits of children (Lytle et al., 1996; Powers et al., 2005; Reynolds et al., 1999; Worsley, 2002).

Thus, we may assume that providing topics on nutrition in primary schools can contribute to forming healthy life styles of children and young persons undergoing compulsory formal education.

In view of the risk factors, which are due to improper diets of children and young persons, the researchers agree in that nutrition recommendations and school syllabi should be adapted to cultural characteristics of a particular group. Nutrition strategies aiming at children and young persons should therefore become a priority at the national level (Rodrigues et.al., 2004; Schneider, 2000).

The Slovene Food and nutrition action plan 2005 – 2010), adopted in 2005, envisages numerous measures for the promotion of healthy nutrition of children and young persons aiming to acquire healthy nutrition habits and change nutrition attitudes. The plan proposes actions for promoting healthy nutrition both, for children and young persons as well as parents. The activities are planned to be implemented through the mass media, in schools, student residences and local communities. Thus, the program of nutrition policy establishes the implementation of programmes for general promotion of health, healthy nutrition and healthy life styles to all training and education institutions and introduces these topics into school curricula of elementary, vocational and secondary schools (Maučec Zakotnik et al., 2005).

In the curriculum of nine-year primary schools various topics on nutrition are included, mainly offered through science subjects. Thus, for instance, the syllabi for the compulsory subject of Home Economics and elective subjects Modern ways of food preparation, and Nutrition which are taught in the third triad of the nine-year primary schools provide numerous teaching topics for acquiring knowledge and skills in nutrition. The nutrition education is most intense in the 6th grade and is offered within the Home Economics course (Koch & Kostanjevec, 2005)

Most studies in which the researchers analysed the impact of nutrition education on nutrition behaviour of children have been focused on the analyses of the effects of nutrition education and were targeted at specific populations and educational contents (Jaycox, 1983; Salminen et al., 2005; Barlov & Dietz, 1998).

Persons who undergo the process of informal education are usually internally motivated. Consequently, this has positive effects on the outcome of education. On the other hand, in formal education, which is compulsory for all children, motivational levels are different and prior to education children have already developed certain nutrition behaviour and dietary habits which come as a result of biological and internal or external psychological and social factors.

The results of research, in which the impacts of nutrition education on nutrition behaviour and nutrition knowledge were studied and analysed, have brought different results. Understanding different factors which influence nutrition behaviour of children is the first step to forming efficient measures which may change nutrition behaviour (Cullen et al., 2000).

Some studies confirm the hypothesis that it is possible to improve nutrition behaviour and nutrition knowledge by proper educational programmes (Powers et al., 2005; Worsley, 2002; Reynolds et al., 1999). Axelson et al. (1985) studied the correlation between the nutrition knowledge and nutrition behaviour in adults, children and young person to find out that the correlation was very low (r = 0.10).

The results of analyses of the impacts of formal education on nutrition knowledge and nutrition behaviour of children and young persons can, to a certain extent, prove suitability and efficiency of educational programmes and teaching aims and indicate how nutrition knowledge has improved, or influenced nutrition behaviour of children.

The purpose of our research was to find out how suitable the nutrition education in elementary schools in Slovenia is.

By analysing variables at the beginning and at the end of educational process we could measure and analyse the impact of formal nutrition education on the nutrition knowledge of pupils. In addition, we were able to observe the changes in their nutrition habits. By determining the level of changes of individual variables due to nutrition education we could critically evaluate the impacts of nutrition education on nutrition behaviour of pupils.

METHODS AND RESULTS

Sample

The purpose of our research was to analyse nutrition knowledge and nutrition habits of eleven-year-olds from 28 schools in Slovenia. The research sample included 630 pupils who attended the course of Home Economics in school year 2006/2007. We administered the first knowledge test in September 2006, at the beginning of the course, and in May 2007 after the completion of the course. The course was compulsory for all pupils.

Nutrition education

It was found out that in all schools participating in the study, the home economics courses were in agreement with the curriculum for the 6^{th} grade of elementary nine-year programme. In some schools courses were adapted to the specific conditions of a school and their programmes. According to the curriculum, home economics course for 6th graders takes 52.5 hours.

Table 1. Number of hours of home-economics courses and number of hours devoted to nutrition topics in 2006/2007

	Home economics (hrs)	**Nutrition topics (hrs)**
M	50,7	38,6
Min	15,0	26,0
Max	55,0	45,0

From the Table 1 we can see that on the average children had 50.7 hours of home economics, and 38.6 hours were devoted to nutrition topics. Teachers applied different teaching methods, mainly group work. Children worked either in pairs or in small groups, less frequently individually, or the teacher presented the topic frontally.

Testing of knowledge

The pupils' nutrition knowledge was tested by a written test given at the beginning and at the end of the course on nutrition. The test included 27 test items. Test items covered thematic units and were designed according to the knowledge standards prescribed by the home economics syllabus. Thematic units are listed below:

- nutrients and energy,
- energy value of foodstuffs,
- nutritional value of foodstuffs,

- ingredients in foodstuffs,
- foodstuffs groups,
- groups of foodstuffs according to the content of nutrients,
- energy needs,
- the role of nutrients in human body,
- impacts of nutrition on human health,
- nutrients and human organism,
- nutrition recommendations,
- planning a healthy diet.

In the test we used different types of questions to test assess levels of knowledge according to Bloom's taxonomy. The maximum number of points which could be achieved in the knowledge test was 27.

Nutrition habits

Nutrition habits of children were analysed on the results of a food frequency questionnaire. The measurement instrument for identifying nutrition habits was adapted to HBSC questionnaire (Stergar et al., 2006).

Statistical methods

The data were analysed by statistical software SPSS. In analysing the results of the knowledge test we used the t-test statistical method for dependent and independent variables. The impact of newly acquired knowledge on nutrition habits of children was measured by calculating partial correlation coefficient. In statistical interpretations we considered a 0.050 risk factor.

RESULTS

Nutrition knowledge

The correct answers in the knowledge test were assigned a one point value, and wrong answers a zero value. The maximum number of points was 27. We calculated the total number of points achieved by each individual, separately for the first and the second knowledge test. If we compare the mean values of points collected during the first and the second knowledge test, we can see that during the second test children achieved statistically more significant number of points compared to the first test. In the first test children collected 14.60 points on the average, while in the second test they achieved 15.91 points (Table 2). From the data in Table 2 we can infer that children's knowledge improved after they have taken the course on nutrition.

Table 2. Comparison of mean values of the points collected in the first and the second test

	N	M[a]	SD	t	P
First knowledge testing	524	14.60	3.428	-8.174	0.000
Second knowledge testing	524	15.91	4,008		

[a] maximum number of points possible = 27

Analysis of nutrition knowledge by gender

If we compare the mean values of the points achieved during the first and the second knowledge test we can see that there are no statistically significant differences between the boys and girls in the value of total points achieved during testing. The results are presented in Table 3 below.

Table 3. Mean values of points achieved during the first and second knowledge test by gender

	Gender	N	M[a]	SD	t	P
First knowledge testing	boys	305	14.40	3.569	- 0.758	0.449
	girls	291	14.62	3.460		
Second knowledge testing	boys	285	15.57	4.050	- 1.134	0.257
	girls	269	15.96	4.061		

[a] maximum number of points possible =27.

The average number of points the boys achieved during the first testing was (M = 14.52). The result is statistically significantly different from the results the boys achieved during the second testing (M = 15.81). From this we may infer that the boys improved their nutrition knowledge (Table 4).

Table 4. Comparison of the mean values of points achieved during the first and second knowledge testing – boys

	N	M[a]	SD	t	P
First knowledge testing	268	14.52	3.471	-5.835	0.000
Second knowledge testing	268	15.81	3.909		

[a] maximum number of points possible =27.

In the group of girls, the average number of points achieved during the first knowledge testing was (M = 14,68), and is statistically different from the results the girls achieved during the second testing (M = 16,01). As we can see from the results in Table 5 below, the nutrition knowledge of girls improved.

Table 5. Comparison of mean values of total points achieved during the first and second knowledge testing – girls

	N	M[a]	SD	t	P
First knowledge testing	256	14.68	3.386	-5.715	0.000
Second knowledge testing	256	16.01	4.114		

[a] maximum number of points possible =27

Impact of education on nutrition habits

Using the method of partial correlation we excluded the linear impact of nutrition knowledge at the beginning of the school year to the correlation between variables in the knowledge at the end of the school year and frequency of meal consumption, or particular foodstuffs consumption.

The analysis of the results shows that the knowledge which resulted from the course on nutrition had no significant impact on daily meal consumption among the children tested. While correlations are statistically significant, and correlation coefficients are positive, they are very low (r < 0.20), which means that correlations are statistically negligible and there are no statistical correlations (Table 6).

Table 6. Partial correlation between nutrition knowledge and food consumption frequency (K2T2.K1).

Meal	Nutrition knowledge (2nd knowledge testing)	
	r	P
Breakfast	0,040	0,188
Morning snack	0,141	0,001
Lunch	0,073	0,054
Afternoon snack	0,119	0,005
Dinner	0,084	0,032
TOTAL meals	0,151	0,001

Legend:
K1 – knowledge (1st test)
K2 – knowledge (2nd test)
T2 – food consumption frequency (2nd survey)

By calculation of partial correlations between the fast-food consumption frequency and nutrition knowledge of children at the end of the school year showed a negative correlation but statistically significant for the consumption of french fries and hamburgers, as well as for the total consumption of food categorised as fast food. In all cases described we have established that the negative correlation is negligible and that there is no statistical correlation (r < 0.20). Negative statistical correlation shows that children with better nutrition knowledge less frequently consume fast food compared to other children with poor nutrition knowledge (Table 7).

Table 7. Partial correlation between nutrition knowledge and frequency of fast food consumption (Z2P2.Z1).

Food	Nutrition knowledge (2nd testing)	
	r	P
Sandwich	-0.016	0.365
Pizza	-0.071	0.059
French fires	-0.100	0.014
Hamburger	-0.088	0.027
Fast food TOTAL	-0.006	0.450

Legend:
Z1 – knowledge (1st testing)
Z2 – knowledge (2nd testing)
P2 – frequency of meals (2nd survey)

We have also analysed the impact of nutrition education on the consumption of particular foodstuffs in children. The calculation of partial correlation showed that for some types of food (e.g. meat, cereals) there is a negligible statistically significant correlation ($r < 0.20$) between the nutrition knowledge acquired and frequency of a particular food consumption. By calculating partial correlations we found out that there is also a negligible negative statistical correlation between the knowledge acquired and frequency of consuming soft drinks, energy beverages or alcohol.

CONCLUSION

As already established by the authors Conner and Armitage (Conner & Armitage, 2002), education and nutrition knowledge do not necessarily have any direct effect on the nutrition behaviour of individuals, however this may significantly influence the attitudes and other psychosocial factors which influence nutrition behaviour.

It was found out that, statistically, the knowledge of pupils significantly improved after they had finished the learning process. The analysis of the knowledge showed that pupils know the basic principles of healthy nutrition which they have already acquired at the lower levels of their schooling. Considering how nutrition topics are presented in Home Economics as a school subject, we can conclude that Home Economics mainly focuses on acquiring skills and less on acquiring theoretical knowledge. In nutrition education, the sixth graders of the primary schools are faced with concepts which, according to their level of cognitive development, are too difficult to understand and this may have resulted in their knowledge. For example, to understand the role of nutrients, or topics related to food energy values, pupils need to employ abstract and hypothetical mind operations which may be very demanding at this age. We did not find any statistically significant differences in the knowledge between boys and girls. We believe that larger differences may be expected in higher grades of primary school.

One of the operative aims of the home economics curriculum is that learners, after completing the course on nutrition, should be able to analyse human needs for nutrients and energy in food, and should be able to know the nutrient value of foodstuffs, and thus be able to classify food into groups. Considering the cognitive level of children who participated in the study we can expect that children become capable of dealing with more complex problems at a later stage, i.e. in higher years of compulsory education. Therefore, it is necessary to integrate nutrition topics into the syllabi in the last triad of elementary schooling. The existing syllabi, which contain topics on nutrition, need to be adapted to the corresponding cognitive development level of children, and children need to be introduced with the latest findings in nutrition science, where particular concepts which are used in nutrition education need to be clearly defined.

By determining the level of changes of particular variables measured due to the influence of nutrition education it is possible to critically evaluate the existing nutrition topics and curricular aims for elementary schools. Formal nutrition education, which is carried out at the 6th grade of elementary schools in Slovenia, has proved to be successful from the aspect of acquisition of new nutrition knowledge. A detailed analysis of knowledge test results showed that general knowledge about nutrition is good, while children lack the knowledge to be able to explain more complex problems related to healthy nutrition.

Based on our results we propose that there should be more hours devoted to nutrition education in schools, and that nutrition education should be provided throughout the course of elementary school programme. Only in this way we can expect better quality and permanence of the knowledge acquired, which would consequently lead to the formation of healthy nutrition habits of children. Nutrition education needs to be carefully planned and continuously provided, also beyond elementary schooling, i.e. at the secondary and tertiary level. What is important is that we allow for continuous upgrading of the knowledge and bring in interdisciplinary approach. Nutrition education should be of national interest if we want to improve nutrition habits and lifestyles of Slovenian people.

Therefore, the aim of nutrition education should be to qualify children for problem solving in questions related to nutrition, which means developing analytical and logical thinking. Only a sound and reinforced nutrition knowledge can contribute to the formation of positive attitudes towards healthy nutrition among children, which later, during the period of adolescence, will result in the formation of healthy nutrition habits, meaning that there is a lesser chance for children to become influenced by their peers and acquire bad nutrition habits.

Nutrition education of young persons requires activities and methods which would promote and reinforce self-efficacy in terms of healthy eating. Education will only become more efficient if we are able to remove the factors which hinder the development of healthy nutrition habits of young persons and enable access to healthy food (Gracey et al., 1996).

Worsley (2002) found out that while on the one hand nutrition education is necessary, it alone is insufficient to bring changes into nutrition behaviour of persons. Children need to be constantly encouraged to consume healthy food, which means that suitable environment needs to be created. Equipped with good nutrition knowledge, children will be able to develop suitable and good quality life styles. Consequently this will help them to take responsibility for their continuous personal development and hence the development of the society as a whole.

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GHANAIAN URBAN AND RURAL JUNIOR SECONDARY SCHOOL PUPILS' OPINIONS OF THE ROLE OF SCIENCE AND TECHNOLOGY IN SOCIETY: IMPLICATION FOR SCIENCE, TECHNOLOGY AND SOCIETY EDUCATION

Ishmael K. Anderson

University of Education, Winneba, Ghana

ishkandy@yahoo.com

ABSTRACT

The paper probes into how Junior Secondary School (JSS) pupils in the Central Region of Ghana perceive the role and function of science and technology in society. In the year 2003, 613 and 414 final year pupils from urban and rural schools respectively were used for the study. Subjects responded to one of the themes of a standardized Relevance of Science Education (ROSE) survey questionnaire of which the items are statements about some aspects of science and technology issues, all on 4-point Likert-type scale. An independent sample two-tailed t-test was used to determine the differences in the items' mean values between the two groups at $p \leq 0.05$. Findings were that urban and rural pupils expressed almost similar views about issues of science and technology. However, very few differences in opinions between urban and rural pupils were found to be statistically significant. The paper concludes that the emotional disposition of pupils towards the role and function of science and technology in society might translate into high motivation in pupils for any sound science, technology and society (STS) education.

Keywords: *Ghana, urban and rural settings, school pupils, STS education, science curriculum, geographical background.*

INTRODUCTION

Any country striving to develop in order to raise the standard of living of its population and maintain a balanced economy must as a matter of necessity adopt science and technology as the basis for achieving sustainable development. Science and technology continues to play an important role in the areas of food production, protection against and treatment of diseases and waste management. In these areas, engineers and technologists with their expertise may have the opportunity to help and make the world a better place to live (Schreiner, 2006). Ghana, as a nation, recognizes the importance of science and technology in national development. Hence, since the attainment of independence, successive governments have endeavoured to make science and technology a basis for the country's development (Anamuah-Mensah, 1994).

According to Sjøberg (2002a), education in science and technology are the most important areas of the curriculum to enable people to make sense of the world and to use the resources at hand. Therefore, for Ghana to develop there is the need to support the rapid development of scientific and technological literacy among all individuals. Science and technology education should therefore be given high priority in the school curriculum.

As a result of the increasing consciousness of the importance of science and technology in social and environmental issues, there have been attempts in Ghana to initiate science, technology and society (STS) programmes in all educational levels. These efforts to foster STS approaches to school science and related curriculum fields appear to have met challenges. It appears some of the challenges are that as science and technology are becoming increasingly important in changing society and people's lives, many pupils simultaneously experience school science as irrelevant to their present and future lives. It has also been mentioned in a study that STS materials have not changed the phase of school science to any appreciable level but rather served the function of supporting and enriching otherwise conventional school science courses (Jenkins, 1992). This is because efforts to identify courses, titles and special projects which have common features of STS to embrace all backgrounds or social class appear to meet with difficulties.

It is a fact that the current practices in science and technology education have the goal to develop scientifically literate individuals who are able to use their knowledge in their everyday decision-making and not to turn everyone into a scientist. These individuals are to appreciate the values of science and technology in society and understand their limitations. However, another challenge confronting science and technology education is how to change our goals from that of academic preparation for science careers for a few individuals to start individuals on the road to critical thinking, to better problem-solving ability, and to become better citizens in this increasingly technical world (Yager, 1996). Furthermore, in the face of the current global trends, there is a demand for science and technology education to emphasize preparing all pupils to engage successfully with science and technology in their own, everyday lives, as well as to participate knowledgeably in important science and technology-related issues. This calls for a shift from an academic curriculum design towards a social curriculum design. With this, the scientifically literate person can use concepts of science, technology and ethical values in solving everyday problems and making responsible everyday decisions in everyday life.

Pupils in general appear engrossed in current technological developments and perhaps use them to see the importance and relevance of science concepts. However, they also appear to recognize the strengths and limitations of science and technology for advancing human welfare (Yager, 1996). Consequently, relevance of STS is not a means to technology education since the latter focuses on the teaching of the technical aspect of technology and it is, therefore, not considered among the approaches to STS education (Pacey, 1983).

Equity with respect to social class or geographical background is on a high list of political, social and educational concerns in Ghana. The urban and rural communities in Ghana are in the extremes with respect to most statistical indicators, like educational level, income, and occupational pattern. The perceived isolation of rural schools and a low population density create an additional set of challenges to science education. A study by Zuniga, Olson and Winter (2005) indicates that a sense of isolation and low population density make opportunity fewer for pupils in rural schools. It is even argued that the lack of educational resources, most often occurring in rural communities, has a demoralizing effect on teachers to teach science (Fredua-Kwarteng & Ahia, 2005). Children growing up in these two different communities represent great disparities in the Ghanaian context. This might expect them to demonstrate very different interest profiles at school science. However, in a world filled with the products of science-based technology, everyone needs to be equipped with skills to engage intelligently in public discourse and debate about important issues that involve science and technology in a society. Such skills can be realized through a high quality STS education.

Hence, it is justifiable to elicit the opinions of both urban and rural school pupils on how they perceive the role of science and technology in society, including opinion patterns that might emerge. This is because empirical evidence shows that the level of technological development in a community or country is a key factor for explaining the expectations people have of further developments in science and technology (Schreiner, 2006).

METHODOLOGY

A descriptive research design was used to survey urban and rural JSS pupils' opinions about the impact of science and technology on society.

POPULATION AND SAMPLE

The target population was all urban and rural junior secondary school (JSS) pupils at the terminal class (JSS3 or ninth grade) of the compulsory schooling in the Central Region of Ghana in the year 2003. One JSS from an urban area and another one also from a rural area in each of the twelve (12) districts of this region were considered. Within these schools, a sample of 613 and 414 pupils were selected from urban and rural settings respectively, to participate in this study.

The choice of JSS3 is based on the recognition that at this level most of the pupils would have reached the age of 15 years. At that age pupils are expected to be mature and hence likely to undertake conscious reflections on their interest, priorities and attitudes to comprehend science and technology-related issues. In Ghana, it is also the age when many educational and curricular choices are made. Therefore, it is likely that at that age pupils will give consistent responses to the questions and thereby enhance the reliability of the data.

DATA COLLECTION AND ANALYSIS

One of the subsets of a standard ROSE questionnaire labelled G and with a theme "My opinions about science and technology" (Appendix A) was used to collect a purely quantitative data. The 16 items of this subset tapped into pupils' perception about the role and function of science and technology in society, as well as their expectations of science and technology. The items are on issues about science and technology, each on a 4-point Likert scale from 'Disagree' to 'Agree'. The Likert scale which was used is regarded in this study as quasi-interval scale (Schreiner, 2006). This assumption has an advantage in that, data in such an interval scale can be manipulated by addition and subtraction, and therefore can be used in the most common statistical procedures (Ary, Jacobs & Razavieh, 1996 cited in Schreiner, 2006). The acceptance to use the Likert scale as a method of scaling in this study is based on its widely mentioned use in the literature (Robson, 2002; Neuman, 2000; Gable & Wolf, 1993). It is also the most common method of scaling in international surveys like TIMSS, PISA and Eurobarometer. A 'neutral' point with a mean score of 2.5 is the middle mark on the 4-point Likert-type scale, which represents a position in their responses. This position indicates an option by majority of the pupils but not all, where they neither disagree nor agree to an item.

Data obtained using the standard ROSE questionnaire on the above theme were analysed through the use of SPSS version 12.0.1 for Windows (SPSS Inc., 2003) and Excel. Descriptive statistics was conducted on data obtained to provide documentation on general expectations of pupils for science and technology. An independent sample 2-tailed t-test was used to explore the statistical significance of the differences in the items' mean at a conventional $p \leq 0.05$ level of probability to report whether significant differences existed between the groups of pupils' responses by geographical location.

ROSE PROJECT

The ROSE is an international cross-cultural comparative research project basing its theoretical framework on the affective domain aspects of science and technology learning with about 15 year-old cohorts. Information about the project including questionnaire and countries involved is found in Schreiner and Sjøberg (2004) and also at the website (http://www.ils.uio.no/forskning/rose/).

RESULTS AND DISCUSSION

The views expressed by both urban and rural junior secondary school pupils concerning the roles science and technology play in a society appeared to be positive. The positive views were shown clearly in their responses on all the listed issues about science and technology, which had mean values greater than 2.5. The mean range of responses to each of the statements for urban pupils was from 3.55 to 2.63 and from 3.58 to 2.62 for rural school pupils. Based on these mean values, it appears both urban and rural school pupils have high expectations for science and technology.

In Table 1, the results are presented in an increasing order of popularity of opinion among urban and rural school pupils. The most popular expressed opinions are considered and then followed by the less frequently mentioned issues about science and technology in society. All the numbers are mean values of pupils' responses to each of the roles and functions of science and technology in society. However, the mean values greater than 3.0 are presented for both urban and rural pupils in Table 1.

Urban and rural school pupils' responses appeared to emerge in a similar pattern. Most pupils from both urban and rural communities appeared confident about the possible achievements of science and technology. The majority of the urban and rural pupils seemed to have a strong belief in the following aspects of science and technology (see Table 1).

Though there are some differences in opinions between urban and rural pupils about science and technology, most of the differences appeared to be of no educational significance. Both groups held similar positive views on the list of aspects of science and technology. However, five out of sixteen items showed statistically significant differences with p-value less than 0.05 (Appendix B). These significant differences are also shown in Figure 1. On the average, there were three aspects of science and technology issues, which urban school pupils agreed more than their rural counterpart. For the rural pupils, they had more belief in two aspects of the science and technology issues.

Table 1 Urban and rural pupils' most important aspects of science and technology in society (mean score value >3.0). Mean values sorted in descending order. Items appearing on both lists are in boldface.

	Urban pupils' opinions	Mean
G1	**Science and technology are important for society**	**3.55**
G4	**Science and technology make our lives healthier, easier and more comfortable**	**3.44**
G11	**A country needs science and technology to become developed**	**3.36**
G3	**Thanks to science and technology, there will be greater opportunities for future generations**	**3.35**
G5	**New technologies will make work more interesting**	**3.33**
G2	**Science and technology will find cures to diseases such as HIV/AIDS, cancer, etc.**	**3.21**
G13	**Scientists follow the scientific method that always leads them to correct answers**	**3.19**
G12	**Science and technology benefit mainly the developed countries**	**3.10**
G6.	**The benefits of science are greater than the harmful effects it could have.**	**3.08**
	Rural pupils' opinions	Mean
G1	**Science and technology are important for society**	**3.58**
G4	**Science and technology make our lives healthier, easier and more comfortable**	**3.40**
G11	**A country needs science and technology to become developed**	**3.37**
G5	**New technologies will make work more interesting**	**3.34**
G3	**Thanks to science and technology, there will be greater opportunities for future generations**	**3.26**
G2	**Science and technology will find cures to diseases such as HIV/AIDS, cancer, etc.**	**3.23**
G6	**The benefits of science are greater than the harmful effects it could have**	**3.09**
G13	**Scientists follow the scientific method that always leads them to correct answers**	**3.04**

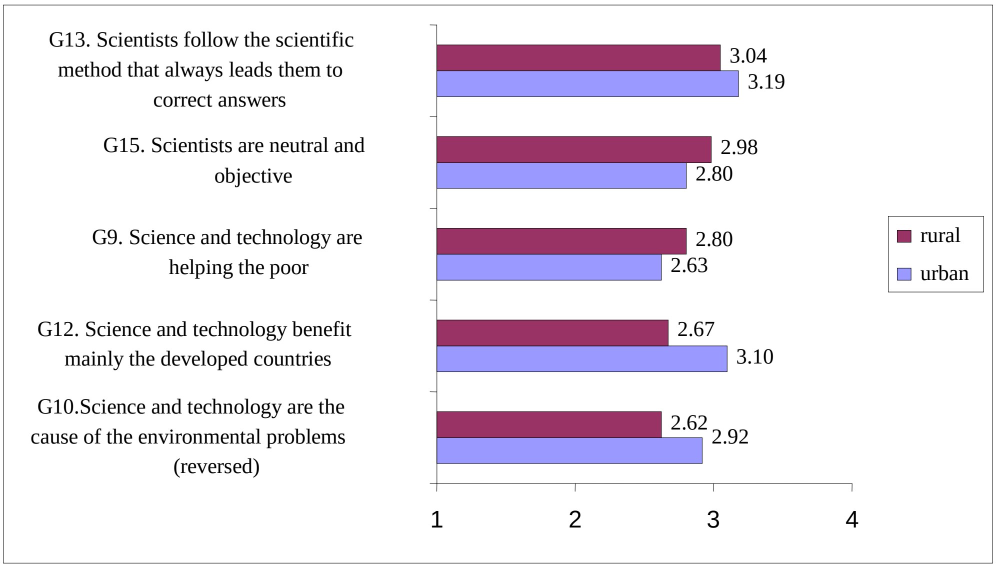

Figure 1. Statistically significant differences (p<0.05) in opinions for rural and urban school pupils. Mean values sorted in descending order for rural pupils.

The responses given by pupils on science and technology issues showed that both urban and rural school pupils had high regard for science and technology. This is because the mean values of their responses appeared to indicate that they strongly agreed with a number of issues concerning science and technology in society. Some of their perceptions of science and technology were that science and technology are important for society and also can make our lives healthier, easier and more comfortable. These perceptions might explain why the majority of urban and rural pupils in this study demonstrated in their responses that a country needs science and technology to become developed and that new technologies will make work more interesting.

Schreiner and Sjøberg (2007) and also Schreiner (2006) have all indicated in their studies that in developing countries, pupils' immediate concerns about the application of science and technology are for general improvement and welfare of their societies. Perhaps this observation might be one of the reasons that pupils' opinions surveyed showed a great respect for science and technology. With regard to the respect for science and technology, they seemed also to have a strong belief that through science and technology there will be greater opportunities for future generations. Scientists were seen as very brave and intelligent people who follow the scientific method that always leads them to correct answers. Furthermore, there was the belief that scientists can help people by finding cures to diseases such as HIV/AIDS and cancer. An interesting aspect of their responses was that science and technology was seen as having more benefits than harmful effects. These high expectations of pupils for science and technology appear to link well with their high levels of interest to learn science and technology-related issues at school (Anderson, 2007).

As indicated earlier, the beliefs in several aspects of science and technology shown by pupils in the poor and underprivileged part of the world have been mentioned in some studies (Sjøberg, 2000; Sicinski, 1976). The results from this study of both urban and rural pupils from Ghana revealed that pupils from these two different geographical areas held positive views about issues of science and technology. They appeared to show no emotional disposition towards the possible negative effects of the advancement in science and technology. Perhaps, their focus is on how science and technology can improve the general welfare of society and therefore, their immediate concern might not be associated with some of the possible adverse effects of science and technological application in society. Against this background, the perceived negative characteristics associated with scientists are not likely to emerge at early stage of schooling. This assertion is in line with some studies in science education which revealed that scientists continue to enjoy the position of respect in the developing societies (Sjøberg, 2000; 2002b).

In view of the fact that urban and rural school pupils are from two different environments, the differences in their opinions about science and technology issues in society were not pronounced. Issues that were perceived to be important by one group were also of equal importance to the other. Both urban and rural pupils perceived that scientists are neutral and objective and that science and technology are helping the poor.

When opinions were sought between urban and rural pupils about whether science and technology had played any role in the development of the world, the responses revealed a large difference in opinion between the two groups. Urban pupils agreed more to the statement than rural pupils that science and technology benefit mainly developed countries (mean value was 3.10 as against 2.67 for rural pupils). Urban school pupils also were less in support of the statement that science and technology are the causes of the environmental problems. This statement, however, was reversed and the mean values were 2.92 and 2.62 for urban and rural school pupils respectively. A mean response value of 2.62 appears to indicate that most rural pupils were somehow indifferent to the statement since a value of 2.62 is on the right and closer to the neutral response value of 2.5.

For rural pupils, the stronger belief that science and technology are helping the poor appears to correlate well with their lesser belief that science and technology benefit mainly developed countries. On the other hand, urban pupils were less in agreement that science and technology are helping the poor. This also seems to correlate well with their strong perception that science and technology benefit mainly the developed countries. Pupils in rural communities are confident that advancement in science and technology might have the capability of reducing incidence of poverty and other challenges.

IMPLICATION FOR STS EDUCATION

Looking at these responses as the true reflections of their opinions about science and technology, certainly, such views of the pupils could influence their motivation and willingness to engage in schooling that is more associated with science and technology. Since the JSS is a terminal point for the formal education of most pupils, it is at this point that scientific knowledge and attitudes need to be strengthened. A key concern for the reworking of the science curriculum when it is opened for negotiation is to re-establish relevance, meaning and significance of science learning based on changes in science and technology and their role in society.

In this study, it has become obvious that the young urban and rural learner may have developed awareness and appreciation of scientific and technological activities, and interdependence of scientific, socio-economic and technological changes in Ghana and other countries. An important thing now is to identify courses, topics and projects to feature well in STS education that should interest both groups of learners. This could be done by bringing faculty from social studies and science together to mount courses, which meet the requirements in science or in social studies. Interestingly, both groups of learners, irrespective of their backgrounds, have demonstrated in the opinions a common interest in science and technology issues. Hence a search for courses and topics in STS education might not meet with much difficulty. In these courses and topics pupils are likely to attain and retain many skills and competencies defined as science literacy since they meet their interest. Such skills and competencies could be difficult to develop as a result of study in standard (traditional) science courses. This is because in STS classes, pupils are expected to be motivated to see science concepts as personally useful and can relate them to new situations. However, the practical situation in rural areas in Ghana in the face of our economy may challenge the enthusiasm for rural school pupils to participate equally in STS education as their urban counterpart. Educational policy makers need to capitalize on such interests of pupils towards science and technology issues. These educational policy makers need to rethink curriculum and resources that will be more accessible within STS education in this era of science for all. All these efforts are aimed at producing scientifically literate people that can compete effectively in a globalized knowledge-based economy.

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APPENDIX A: QUESTIONNAIRE

To what extent do you agree with the following statements?

(Give your answer with a tick on each row. If you do not understand, leave the line blank.)

	Disagree	Slightly Disagree	Slightly Agree	Agree
G1.Science and technology are important for society..................................	□	□	□	□
G2.Science and technology will find cures to diseases such as	□	□	□	□
G3.Thanks to science and technology, there will be greater	□	□	□	□
G4.Science and technology make our lives healthier, easier and	□	□	□	□
G5.New technologies will make work more interesting................................	□	□	□	□
G6.The benefits of science are greater than the harmful effects it could have...	□	□	□	□
G7.Science and technology will help to eradicate poverty and famine in the world...	□	□	□	□
G8. Science and technology can solve nearly all problems	□	□	□	□
G9. Science and technology are helping the poor	□	□	□	□
G10.Science and technology are the cause of the environmental problems...	□	□	□	□
G11.A country needs science and technology to become developed	□	□	□	□
G12.Science and technology benefit mainly the developed countries..........	□	□	□	□
G13.Scientists follow the scientific method that always leads them to correct answers..	□	□	□	□
G14.We should always trust what scientists have to say	□	□	□	□
G15.Scientists are neutral and objective	□	□	□	□
G16.Scientific theories develop and change all the time	□	□	□	□

Appendix B

Urban/rural differences in opinion about S&T

Mean values and standard deviation (SD) for urban and rural pupils on the whole list of statements on science and technology. The list is sorted by the urban-rural difference in ascending order. Items where there is a statistically significant (p<0.05) difference, p-values are in boldface.

Statements (items) on science and technology	Urban	Rural	Mean Difference	
	Mean(SD)	Mean(SD)	Urban-Rural	p-value
G15. Scientists are neutral and objective.	2.8 (1.03)	2.98 (1.08)	-0.18	**0.008**
G9. Science and technology are helping the poor.	2.63 (1.17)	2.8 (1.2)	-0.17	**0.021**
G16. Scientific theories develop and change all the time.	2.93 (1.07)	2.99 (1.09)	-0.06	0.343
G1. Science and technology are important for society.	3.55 (0.83)	3.58 (0.84)	-0.03	0.643
G8. Science and technology can solve nearly all problems.	2.91 (1.07)	2.94 (1.08)	-0.03	0.596
G2. Science and technology will find cures to diseases such as HIV/AIDS, cancer, etc.	3.21 (1.07)	3.23 (1.05)	-0.02	0.831
G5. New technologies will make work more interesting.	3.33 (0.83)	3.34 (0.91)	-0.01	0.778
G6. The benefits of science are greater than the harmful effects it could have.	3.08 (0.97)	3.09 (1.04)	-0.01	0.850
G11. A country needs science and technology to become developed,	3.36 (0.89)	3.37 (0.92)	-0.01	0.849
G7. Science and technology will help to eradicate poverty and famine in the world.	2.9 (1)	2.9 (1.17)	0.00	0.979
G4. Science and technology make our lives healthier, easier and more comfortable.	3.44 (0.89)	3.4 (0.93)	0.04	0.499
G3. Thanks to science and technology, there will be greater opportunities for future generations.	3.35 (0.86)	3.26 (0.95)	0.09	0.134
G14. We should always trust what scientists have to say.	2.95 (1.01)	2.84 (1.1)	0.11	0.137
G13. Scientists follow the scientific method that always leads them to correct answers.	3.19 (0.94)	3.04 (1.05)	0.15	**0.023**
G10. Science and technology are the cause of the environmental problems	2.92 (1.19)	2.62 (1.23)	0.30	**0.000**
G12. Science and technology benefit mainly the developed countries.	3.1 (1)	2.67 (1.2)	0.43	**0.000**

A CASE STUDY ON TEACHER LEARNING TO TEACH NATURE OF SCIENCE

Ching LAI

The University of Hong Kong

lightchain@gmail.com

Benny, Hin Wai YUNG

The University of Hong Kong

hwyung@hkucc.hku.hk

ABSTRACT

A case study on teacher learning to teach Nature of Science

This paper reports the case of a teacher, Gloria, about her learning in the first nine months of a Teacher Professional Development (TPD) program which aims at preparing teachers teaching Nature of Science (NOS) in the new curriculum reform in Hong Kong. Upon reflection of her learning, Gloria highlighted the importance of leaving enough time for student's discussion and the importance of "wait time" in teaching students about nature of science. When Gloria was asked to identify ideas about NOS teaching that she would like to share with other teachers in a study group meeting of the TPD program, without hesitation she picked on the issue of "not to hurry things". This paper examines how this important learning for Gloria is related to the explicit and reflective approach advocated in the literature on teaching of NOS. The processes of how Gloria came to learn about this in the TPD program will be presented and discussed. Lastly, implications are drawn regarding the design of an effective TPD program for helping teachers to learn how to teach NOS.

Keywords: *Nature of Science, Teacher Professional Development*

INTRODUCTION

Understanding nature of science (NOS) has long been regarded as a major component of scientific literacy and an important learning objective of science curricula in many countries (American Association for the Advancement of Science [AAAS], 1989, 1993; Council of Ministers of Education, Canada [CMEC], 1997; National Research Council [NRC], 1996). In line with this international trend, recent development of science curricula in Hong Kong has seen a shift from the predominantly content-focused goal to a wider goal of promoting understanding of nature of science (NOS). This poses a host of problems and challenges in preparing teachers for this new curriculum reform. For example, various studies consistently point to teachers' inadequate understanding of NOS (Lederman, 1992). Other studies also pointed out that, even teachers with sufficient NOS understanding, it is not automatically and necessarily translated into classroom practice (Lederman, 2007). Teachers are, in general, lack of the relevant pedagogical skills for the teaching of NOS. In view of this, a 2-year long teacher professional development (TPD) program has been set up to prepare teachers in Hong Kong for the teaching of NOS. The aim of this paper is to report one of the key learning of a teacher, Gloria, in this TPD program: how Gloria have come to grips with her important learning of "not to hurry things" in the process of teaching NOS; and how various factors in the program had contributed to her learning.

THEORETICAL UNDERPINNINGS

Instead of a complete review of all the relevant literature, this session presents studies that informed the design of the present TPD program.

SEARCHING FOR AN EFFECTIVE APPROACH OF TEACHING NOS

Much research efforts have been placed to improve teachers' conceptions of NOS for approximately fifty years. Some initial TPD programs which attempted to improve teacher's NOS understanding include the work of Welch and Walberg (1968). They investigated the usefulness of a summer institute program for physics teachers. Lavach (1969) discussed the historical development of some science concepts in an in-service program; and Billeh and Hasan (1975) conducted a four-week courses which included 12 lectures related to NOS. Lederman (1992), in his review, summarized that these efforts to improve teacher's understanding have met with some success whey they have discussed historical aspects of scientific knowledge or drawn direct attention to the NOS.

Later on, Abd-El-Khalick and Lederman (2000) conducted another comprehensive review. The aim of this latter review was to compare the 'effectiveness' of two nearly contradictory attempts to improve teachers' NOS conceptions: implicit and explicit approach. Implicit, as implied, means that the understanding of NOS is a result of engaging the learner in scientific inquiry, participating in science-related activities and/or doing science. Whereas, explicit is an approach which intentionally draws learners' attention to relevant aspects of NOS through instruction, discussion, questioning and written work following classroom activities. Based on the studies reviewed, Abd-El-Khalick and Lederman concluded that the explicit approach is relatively more effective in promoting teachers' NOS conceptions than the implicit one. Indeed, other evidence is accumulating to support this claim that an explicit approach, especially with a reflective component, is an effective way in improving teachers' views of NOS (e.g. Abd-El-Khalick, 2001; Abd-El-Khalick & Akerson, 2004; Bell, Lederman & Abd-El-Khalick, 2000; Irwin, 2000). To follow the above suggestions, the present TPD program paid explicit and direct attention to the NOS.

TEACHER PROFESSIONAL DEVELOPMENT PROGRAMS FOR IMPROVING NOS INSTRUCTION

Three recent TPD programs which informed the design of the program described in the present study are discussed below.

Three-year program on elementary teachers' view and practice

One of the studies is by Akerson and Hanuscin (2007). The study aims at tracing the influence of a 3-Year TPD Program on elementary teachers' view of NOS, the instructional practice to promote students' appropriate NOS views, and the influence of participants' instruction on elementary students' NOS views. The design of the TPD program mainly draws upon Bell and Gilbert's (1996) science teacher development model. The model emphasizes three components: (a) personal development in which the teacher must be aware that there is a need for professional development and acknowledge the desire to acquire new ideas or strategies; (b) social development in which the teachers have opportunities to discuss ideas with other teachers, and to collectively renegotiate what it means to teach science and be a teacher of science; and (c) professional development in which the teachers are supported in implementing the new ideas and strategies in their classroom practice, drawing on the changes they make personally and socially. These three components are viewed as essential to building on teachers' commitment to enact changes within their own classrooms and professional communities. Some other characteristics of successful teacher development model employed in this study include providing enough time to allow for acquisition of new views along with practice, feedback, follow-up, allowing the teacher to reflect on the new idea or implementation of the new skill, and allowing the teacher to see the new skill or strategy in practice (Henriques, 1998; Loucks-Horsley, Hewson, Love, and Stiles, 2003). The TPD program finally developed consisted of a series of monthly half-day workshops, as well as regular on-site classroom visits by project staff. Results indicated that the teachers (as well as the students they taught) showed positive changes in their views of NOS and improved science pedagogy. In the discussion part, the authors reported that all aspects of the program had influenced teachers to varied degrees. The individual support for teachers was found to be a critical element of their social development. Participated teachers also reflected that the monthly workshops also influenced their change in NOS views, as well as their instructional practice.

In the present study, due attention will be paid to the three components of Bell and Gilbert's TPD model as adopted in Akerson and Hanuscin's study. First, teachers participating in the present study are likely to be those who feel insecure about NOS teaching but committed to improve their science teaching (as they all joined the present study on a voluntary basis). This, according to Bell and Gilbert's model and supported by Akerson et al's study, is an important first step in their personal development. Hence, the above criterion was considered in selecting teachers for this study. To address the second component in Bell et al's model, i.e. social development, teachers in the present study have had ample opportunities to engage in discourse with peers regarding their practice in study group meetings and during workshops. To address the third component (i.e. professional development), support from facilitators (who are experienced science educators) have been offered to teachers with new ideas and strategies to trial out in their own classroom while they are learning how to teach NOS.

Project ICAN

Project ICAN (Inquiry, Context, and Nature of Science) was a five-year TPD project funded by the National Science Foundation in the United States (Kim, Ko, Lederman & Lederman, 2005). Of interest and relevant to the present study is its requirement of the participants to undertake some microteaching sessions in order to improve their pedagogical skills related to NOS teaching. In Project ICAN, microteaching refers to a peer teaching presentation that mimics what teachers plan to do with their students. These lessons were planned and delivered by teams of teachers. A teacher team consisted of three to four members who were voluntarily changed for each peer teaching assignment. Each lesson was videotaped and afterwards there was a brief discussion of the aspects of NOS addressed as well as ways the lesson could be further improved.

In short, over the five years of the ICAN Project, peer microteaching experiences appeared to be an important professional development experience. These opportunities allowed teachers to become more familiar with teaching NOS and helped them reflect and develop their pedagogical content knowledge (PCK) related to NOS teaching. The development of teachers' pedagogical skills related to NOS teaching in Years 4 and 5 of the project was found to be consistent with students' improved understanding of NOS as revealed by analyses of student work. This result implies that TPD programs should provide teachers with opportunities to plan and implement explicit NOS instruction and to observe and discuss peers' microteaching lessons (Lederman, Lederman, Kim & Ko, 2006).

The present study argues that such opportunities to learn from peers could be more profound and effective if videotapes of NOS instruction in authentic classroom situations could be shared among the participants. This is because microteaching in front of peers cannot reflect a real classroom situation. To overcome this limitation, teachers participated in the present study have been asked to share and examine videotapes of themselves teaching NOS in authentic classroom situations.

Exploring dimensions of effective NOS instruction

Bartholomew, Osborne and Ratcliffe (2004) reported the work undertaken with a group of 11 teachers over a period of a year to teach aspects of the nature of science, its process, and its practices. The program consisted of development of curriculum materials, classroom trial run teaching and workshops. In this project, teachers were asked to develop curriculum materials in the beginning stage of the study. During the first three months of the study, four initial one-day meetings were held. These meetings provided participating teachers an opportunity to explore, plan, and develop materials for the explicit teaching of NOS. However, that had turned out to be a difficult task for teachers to design curriculum materials which explicitly address NOS elements. The researchers therefore drew from a range of existing sources (e.g. Goldsworthy, Watson, &Wood-Robinson, 2000; Ratcliffe, 1999) and worked out lesson outlines and some instructional materials. The researchers later modeled their conception of good practice for the effective teaching of NOS with the developed materials. Such models were offered as framework that teachers could try and adapt. The teachers would then work in age-specific groups to share, develop and adapt the modeled materials and approaches with their own ideas. Teachers then trial run the adapted materials and undertook lessons over a period of two terms. In brief, their findings suggest that effective teaching of NOS requires establishing a context in which it is possible for students to engage in reflexive epistemic dialogue. It requires teachers to shift in the conception of their own role from the dispenser of knowledge to facilitator of learning; a change in their classroom discourse to one which is more open and dialogic; a shift in their conception of the learning goals of science lessons from merely gain in subject knowledge to one which incorporates the development of reasoning and an understanding of the epistemic basis of belief in science; and the development of classroom activities which are owned by students and relevant to their daily life.

The five dimensions of effective NOS instruction suggested provide an initial framework for guiding the design of activities for the TPD program in the present study. They have also an important bearing on the design of the data collection instruments as well as the analysis of data at subsequent stages of the present study.

METHOD AND CONTEXT OF STUDY

This interpretive study on teacher learning is situated in a two-year-long TPD program. As informed by the previous studies illustrated above, there are three distinctive features in this program which aims at improving teacher's NOS knowledge and practice.

FEATURE 1: PROVISION OF CURRICULUM RESOURCES

The decision to provide teachers with curriculum materials for their trial runs has been informed by Bartholomew et al's study (2004) where they found teachers experiencing difficulties in designing their own curriculum materials. In this study, 17 sets of curriculum materials were developed for the explicit teaching of NOS across the biology curriculum. The design of the materials was guided by the notion of *educative* curriculum materials (Ball and Cohen, 1996; Davis and Krajcik, 2005). Teachers were invited to choose two sets of curriculum materials, to modify and to teach in their own classes.

FEATURE 2: MAKING USE OF VIDEO IN TEACHER LEARNING TO TEACH NOS

Other than informed by previous studies, the decision of using video in teacher learning is also supported by substantiate amount of relevant literature (e.g. Black & Atkin, 1996; Putnam & Borko 1997). For example, Sherin (2004) identifies several affordances that videos provide for teacher professional development - video as a lasting record; video can be collected and edited; video affords a different set of practices. In this study, videos of teachers teaching NOS in authentic classroom situations were used systematically to help teachers learning how to teach NOS. Specifically, the trial run lessons of teachers teaching NOS were videotaped. The video clips were then re-played and reviewed in the subsequent study group meetings for discussing the pedagogical issues involved.

FEATURE 3: ORGANIZATION OF STUDY GROUP

It appears that in all the three studies reviewed, peer learning did play a role in helping teachers learning how to teach NOS. In this study, teachers were provided with opportunities not only to learn from peers in form of study groups, but to decide on their own agenda for their professional development in learning how to teach NOS. For example, they were asked to select video episodes which they wanted to bring up for discussion in addition to those selected by the facilitators.

OVERALL DESIGN OF THE TPD PROGRAM

In brief, twelve biology teachers formed themselves into two study groups, each with six teachers and facilitated by a science educator. The teachers worked collaboratively in study group meetings to help each other to learn how to teach NOS. To start with, the teachers were given curriculum materials for teaching NOS using an explicit and reflective approach. They refined the resources and taught the modified curriculum materials in their own classrooms. The lesson videos were then shared and analyzed collaboratively in the study group meetings. Towards the end of the program, the two study groups will come together to share their experiences on themes of common interests in their learning of how to teach NOS. The major TPD activities were listed in table 1.

Table 1: Major activities in the TPD program

Major TPD activities	Descriptions
Briefing session	• Introduce the objectives and the professional support provided by the TPD program
Planning meeting	• Gather teachers in study groups and work for the learning agenda • Introduce strategies for teaching NOS • Initiate the process of refining curriculum resources by teachers
Two-day training workshops on teaching NOS	• Consolidate teachers' knowledge base on NOS the relevant pedagogical content knowledge (PCK) for the teaching of NOS • Content: common myths about NOS; planning a lesson on NOS; teaching NOS across a series of lessons; consolidating NOS learning; teaching NOS on unplanned occasions
Pre-trial run discussion	• discuss the lesson plan and the refined teaching materials with facilitator
Trial run	• try out refined package in own classroom
Post-trial run discussion	• Discuss the trial run lesson with other teachers and the facilitator
Study group meetings	• Review and analyze trial run lesson videos in the study group to look for ways of improvements
Thematic workshops (yet to be finished)	• Discuss and share exemplary video cases contributed by each of the study groups
Debriefing meeting (yet to be finished)	• Teachers will celebrate with their peers on their experience in learning to teach NOS. • Teachers will be invited to share and reflect on their learning to teach NOS through the entire TPD program.

For triangulation purposes, multiple data sources were employed in constructing the case of teacher learning reported below. These include: (1) Gloria's reflection tasks completed after two NOS lessons and the corresponding follow-up interviews; (2) her reflection tasks completed after reviewing two NOS lesson videos and the corresponding follow-up interviews; (3) her e-mails, telephone conversations and face-to-face discussions with TPD facilitator concerning planning and teaching of the two lessons; and the researchers' lesson observation and field notes.

FINDINGS

Gloria is an experienced teacher who has taught biology for more than 20 years. She is very enthusiastic in professionally upgrading herself. This is the second time for her to join a similar TPD program on preparing teachers for NOS teaching. This time, one of the key learning Gloria mentioned in her reflection tasks is the importance of leaving enough time for student's discussion. In this paper, the journey of how Gloria have come to grips with her important learning of "not to hurry things" in teaching NOS as well as how various factors in the TPD programs had contributed her learning will be discussed.

LEARNING FROM THE FIRST NOS LESSON: BARRY MARSHALL'S DISCOVERY OF THE CAUSE OF GASTRIC ULCER

1) Planning the lesson

One week prior to her teaching, Gloria sent the lesson plan and refined teaching materials to the TPD facilitator for comment and advice. She had planned to have 4 group discussions, students' poster presentations, whole class discussion, lecturing and playback of a 10-min video clip on a TV interview with Dr Barry Marshall. During the pre-lesson discussions, the

TPD facilitator advised her to trim some of the contents so as to leave enough time for the group discussions. Even though Gloria had agreed to trim down the contents, she failed to leave enough time for the student discussions during the lesson.

2) Reflecting on the lesson

When asked what were her learning and the difficulties in teaching this lesson, the first sentence Gloria wrote in her reflection task was:

> 'I should have left more time for class interaction and group discussion.'

She recalled in one of the group discussions (on the proposal of hypothesis), students had disagreement among themselves, but she did not put aside enough time in her lesson plan for the discussion:

> '⋯ if I have enough time, I would ask students to clarify what they think, or to give comments to other students' ideas…I realize that when I was planning the lesson, I did not think exhaustively enough. After the lesson, I understand that it would be better if there was a bit more time for discussion.'

In a follow-up interview, Gloria explained how she had come to aware of the problem. She pinpointed that the peer interaction with other teachers during the study group meeting had helped her to reflect on this learning.

> "I have been teaching for so many years…of course if somebody observe my lesson (other teachers and the TPD facilitator), they can remind me and tell me which part I can improve. Their opinions are more objective."

3) Reviewing the classroom video

In response to a question on the accompanying task sheet, 'Write down the new insights gained from reflecting on the lesson's video, Gloria put down:

> 'wait time is very important, not to hurry students'

In the follow-up interview, Gloria explained how she had benefited from reviewing her own lesson video.

> 'After I have watched the video, I try to remind myself one thing. Whenever I teach NOS, which requires high-order thinking, I should give more time for the students to think deeply. I do not want them to feel that they have to rush. Even if I say "You don't have to hurry", you are actually pushing them…Because I saw from my video that I did say "We have to be faster" during the class…'

LEARNING FROM THE SECOND NOS LESSON: THE FUNCTION OF NUCLEUS

1) Planning the lesson

Two months later, Gloria conducted another lesson with an explicit focus on NOS teaching. This time, Gloria did not follow the teaching plan suggested in the teaching package. Instead, she chose to spend time on discussing questions in the pre-lesson task that comes along with the teaching package. She planned to discuss 11 questions in a 90 minutes' lesson. The facilitator commented that there were too many questions and student might not have time to discuss all the questions thoroughly.

During a follow-up interview, Gloria acknowledged the support from the facilitator during the planning stage. She said the pre-lesson discussion had helped her to iron out the key questions to be discussed and reminded her how to better allocate the time for discussion.

> *"The facilitator did remind me to let students to work on the questions individually first before having the group discussion… Allotting 3 minutes for students to work on the questions individually is just too demanding for them. So, how to better allocate the time; how to decide which question to present in the limited lesson time are important."*

2) Reflecting on the lesson

Similar to her experience with the first NOS lesson, time management continued to be a main concern for Gloria as revealed in her reflection task of the second NOS lesson. Below are a few of the relevant excerpts:

> *'There were a lot of learning materials in my lesson plan so I needed to decide which part had to be cut.'*
>
> *'It was difficult to allocate the appropriate amount of time for students to work on the questions individually, and then to participate in group discussion and presentation'*
>
> *'Time control in group discussion is much more difficult than what I thought.'*

In the reflection task, Gloria also recalled how she managed not to rush students to finish the discussion in this second trial.

> *'I did not allocate enough time for the discussion. I was a bit hurry. The discussion was a bit overrun. But, finally I managed to let it go. I told myself that just give them more time to discuss… do not rush the lesson...'*

Overall, Gloria treasured the time discussing the questions with the students. In her reflection, she expressed at least *4 times* that she would rather increase rather than cut short the time for students' discussions, as she put it.

> *'I think the (eleven) questions are worth discussing, because students can have the opportunity to think, to discuss and to argue. If I were to conduct the lesson again, I would spend 3 lessons instead of 2 lessons.'*

In responding to the last question of the reflection task, 'Is there anything you would like to share about learning to teach NOS with others?' Gloria put down *'wait time'*.

3) Reviewing the classroom video

In reviewing her lesson video, Gloria highlighted several episodes where she was concerned about her time management for class discussion. For example:

> *'For the first group discussion on … , I should have left ample time for group discussion.'*
>
> *'(It is) good to allow students to think on their own before getting into group discussion, especially for questions which are more demanding. The "Think Time" is important'.*

In revisiting the whole learning experience of participating in this study, Gloria found that her personal belief about teaching, her experience of teaching these two NOS lessons, sharing with the peers and facilitator and the opportunity for her to review her own classroom videos contributed to her learning about the paramount importance of time management in discussion.

DISCUSSION

An explicit and reflective approach of teaching NOS has been advocated as an effective way of teaching NOS (e.g. Abd-El-Khalick & Akerson, 2004). In Gloria's case, she had planned for an explicit and reflective approach. She did provide students with a lot of opportunities to experience the kind of discussions that scientists normally undertake in scientific inquiry. However, insufficient time was allotted to the activities. This resulted in students not gaining sufficient experiences of which they could subsequently reflect on; and hence affecting the effectiveness of the lesson (as expressed by Gloria). In other words, Gloria had come to grips with the essence of what it means by a reflective approach. That is, 'leaving enough time for student's discussion' is a prerequisite for adopting a reflective approach in teaching NOS. Without enough time for discussion, students will not have an adequate experience to reflect on from which they can derive their NOS understanding.

Indeed, the importance of wait time for effective teaching in general has long been stressed in the research literature and is well encapsulated by Rowe's (1986) paper entitled Wait time: Slowing down may be a way of speeding up! In his review on math and science studies, Tobin (1987) also came to a conclusion that wait time appears to facilitate higher cognitive level learning by providing teachers and students with additional time to think. However, allow more time for student to discuss and have a long wait time is often 'easy said than done' (e.g. Jegede & Olajide, 1995). Gloria is a case in point. This seemingly trivial and simple learning did not come easy but after a lot of inputs from the peers and TPD facilitator at different stages of the TPD program including pre- and post-lesson discussions, review of lesson videos and study group meetings. Based on Gloria's case, we argue that previous TPD efforts might have underestimated the difficulties and effort required to make teachers realizing 'the importance of leaving enough time for student's discussion and have long wait time' for teaching in general and teaching of NOS in particular. We suspect that much greater efforts will be needed to help teachers improve their practices in this area.

The above findings also provide glimpses of how features of the TPD program had contributed to Gloria's learning. For example, the provision of NOS teaching material provides an initial picture of how an explicit & reflective approach of teaching NOS is like. When Gloria modified and adapted the curriculum materials, she was actually "learning" how an explicit and reflective approach of teaching NOS is. Besides, as noted by Gloria, the facilitator's on-site comments and peer's comments in study group meetings are important reminders to her teaching. Without these comments, Gloria may not be notified where she can make further improvement. She may not realize "wait time" is an important learning to her, even though she is a teacher with 20 years of teaching experience.

Learning is more meaningful when it is embedded in the practice (Liberman, 1986). The provision of the trial run practice serves as first-hand NOS teaching experience to Gloria. As shown in the findings and her reflection, she learned most in teaching the two NOS lessons. The second trial run experience indeed echoed and reinforced Gloria's learning in the first trial lesson.

One of the affordances of video is it capability of allowing fine-grain analysis of teaching (Sherin, 2004). Seeing one's practice in authentic situation will only be possible when having the video technology. We believe that learning to teach NOS will be facilitated by this kind of video analysis. As evident in Gloria's case, because of the opportunity of the detailed analysis of her video, she actually "saw" from her video where she urged student to move faster in discussion and she noticed where she can do much better.

In sum, we argue that an effective TPD program for helping teachers to learn how to teach NOS should consider the provision of the NOS teaching resources, opportunities for trial teaching in authentic classroom situations and discussion with peers and knowledgeable others, and above all, the opportunity to review own classroom videos.

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SOCIO-EDUCATIONAL ASPECTS OF APPLYING COMPUTER-BASED TECHNOLOGIES IN SCIENCE EDUCATION

Vincentas Lamanauskas
Šiauliai University, Lithuania
v.lamanauskas@ef.su.lt

Violeta Šlekienė
Šiauliai University, Lithuania
violeta@fm.su.lt

Loreta Ragulienė
Šiauliai University, Lithuania
fk@fm.su.lt

ABSTRACT

The role of information communication technology (ICT) in education in whole and particularly in science education is very important topic. The growth is characteristic not only at university level but also at other levels of the education system. It is accepted that ICT makes the process of teaching/learning more effective and beneficial whereas the education system starts functioning faster. The implementation of new technologies in the educational process raises new possibilities for both teacher and learner, enhances education quality and makes the educational process more versatile.

Pilot research Student and Computer-Based Technologies was conducted in October – November, 2009. To collect the required data, an anonymous questionnaire was prepared. Research sample consisted of 211 respondents who were 1st year university students (freshmen). In the majority of cases, the students learn to use computer independently, whereas next comes help provided by friends and family members. It has been established that computer-based technologies are very rarely used during the lessons of other subjects. The respondents think that using computer-based technologies in the classroom during the lessons of sciences has the highest impact on cognitive abilities (knowledge acquisition, self-sufficient studies etc.).

Keywords: *general schools, computer-based technologies, pilot research, science education*.

INTRODUCTION

Recently, common interest in using computer-based technologies for the purpose of teaching/learning sciences has significantly increased at international level. Different types of research are carried out to reason the efficiency of the applied technologies, an impact on broadening knowledge etc. Various investigations are conducted in Lithuania. The report of the international Software and Information Industry Association of the year 2000 summarizes more than 3500 studies on applying ICT for educational purposes and presents conclusions indicating that the use of ICT in the educational process can improve teaching/learning as well as may have a positive impact on the final results, attitudes and communication with teachers and other students. On the other hand, applying only the latest training aids cannot guarantee better results of teaching/learning. ICT is an absolutely effective instrument for teaching sciences. For instance, the possibilities of multimedia create conditions for establishing ‘virtual school laboratories’ and doing different imitations (for example, complex natural phenomena, expensive and complicated instruments). Computer-based technologies are widely applied to find connections between real and virtual laboratories and can be incorporated into more and more involved educational technologies. In this case, the application of Augmented Reality Technologies in educational practice can be mentioned as one of the examples. The international project Augmented Reality in School Environments "ARiSE" (http://www.arise-project.org) has revealed interesting results. Research on pedagogical effectiveness has disclosed that these technologies can be an effective instrument for improving the quality of teaching in general (Lamanauskas, Pribeanu, Vilkonis, Balog, Iordache, Klangauskas, 2007). The later performed in-depth research on pedagogical evaluation has also demonstrated positive results (Lamanauskas, Bilbokaitė, 2009). On the other hand, the problem is a choice between virtual and real teaching/learning environment. Real experimentation, examination etc. is crucially important for learning sciences. The researchers notice that both children and adults are strongly motivated by experimenting, discovering and understanding things in their own way (Bilek, Krumina, 2008). Thus, the basic problem is the coordination of real experimentation in the classroom with the experiments conducted in the virtual environment. Chemistry is one of the examples showing that sciences are based on experiments. The examiners find that strong emphasis on ‘pure’ e-learning only cannot be the only choice as most frequently this is a combination of e-learning and face to face or mobile process (Cedere, Priksane, 2006; Lovatt, Finlayson, James, 2007).

Research plays a fundamental role despite the fact that regardless of a growing number of computers in comprehensive school, the immediate use of those in the process of teaching/learning is insufficient due to different reasons. The teacher should be able to take into account and involve in their daily work rapidly changing technologies and new approaches and standards in the education field, which requires a higher performance both for students and teachers (Dudareva, Bruneniece, 2008). Teaching and learning are mainly based on the interaction between a teacher and a student. The before mentioned interaction is also determined by the use of computer-based technologies. Therefore, an important point is constant supervision and evaluation of using these technologies. The received information can help with identifying the existing shortcomings and finding adequate decisions on overcoming the encountered weaknesses which is relevant in terms of managing the educational process. First of all, this is due to the fact that arranging a lesson in the classroom and the methods of teaching/learning using computer hardware differ from that based on a traditional approach. Differently, the carried out sociological research on expanding the use of IT in Lithuanian schools shows that a position on applying IT in the educational establishments is rather limited and a wider application of computers usually ends outside informatics classroom (Bedulskis, 2005). Hence**, the object of research** is the use of computer-based technologies in the process of teaching/learning sciences. **Research is aimed** at establishing the positions of 1st year students on applying computer-based technologies in comprehensive school learning sciences and at disclosing the frequency of using these technologies in the classroom during the lessons on sciences.

RESEARCH METHODOLOGY

General Characteristics of Research

Pilot research *Student and Computer-Based Technologies* was conducted in October – November, 2009. A questionnaire was used as a method of the conducted study that fully corresponds to the Lithuanian context as the respondents were the graduates from different comprehensive schools throughout Lithuania.

The Applied Instrument

To collect the required data, an anonymous questionnaire including four main blocks was prepared.

1. The level of ability to use computer (in total, 30 parameters were included, for example, ability to use programs and documents, ability to operate fail search system etc.).
2. The methods of using computers (5 parameters were included, for example, learned during informatics classes; during classes in other subjects; during extracurricular activities; helped family members, friends etc.; individual learning).
3. The evaluation of the frequency of applying computer-based technologies during the classes of sciences (5 parameters were included, for example, the frequency of using a computer projector by the teacher; the frequency of demonstrations done by the teacher, the frequency of applying computer-based technologies by the students for the purpose of practical experimentation; the frequency of communication between students and teachers outside the classroom etc.).
4. Opinions on applying computer-based technologies during the classes of sciences at school. 20 closed type questions were addressed, for example, using computer-based technologies to make lessons more interesting, to increase motivation, for communication purposes etc.

All four blocks were made of closed type statements, the questions to which are given applying a ranking scale from 1 to 5. Every statement was given the calculated popularity/ability index ($0 \leq PI/AI \leq 1$). The closer is PI value to 1, the more important is the statement to the respondent.

The questionnaire also included a demographical part and some other additional variables (for example, the time the respondent uses computer; the daily average of time the respondent spends on learning using computer-based technologies).

Research sample

Research sample consisted of 211 respondents who were 1st year students.

Table 1. Characteristics of the surveyed respondents (N/%)

Sex	Female	Male	Total
	66/31.3	145/68.7	211/100
Locality	Graduates from city schools	Graduates from regional schools	Total
	95/45.0	116/55.0	211/100
Program of studies	Social sciences	Physical biomedical sciences	Total
	109/51.6	102/48.4	211/100

The field of social sciences was represented by the students of educology, economics, business administration and management. The field of physical and biomedical sciences involved the students of physics, optometry, mathematics, informatics, biology and ecology.

The sample of research consisted of students from four departments of the same university. Though it is not a random sample, however, it is supposed to be reliable due to the precondition that the respondents represent comprehensive schools located at different parts of Lithuania and that the major part of the surveyed participants graduated from these schools in 2009. In fact the choice of the university by students was partly random. From this point of view, the respondents' opinion on using computer-based technologies for the purposes of teaching/learning sciences in comprehensive school is accepted as very important and objective.

Statistical data analysis

To analyze research data, the measures of descriptive statistics (averages, popularity/ability indexes, standard deviations) and the method of data reduction (factor analysis) – multidimensional statistical analysis have been applied. To test equality of means, Independent Samples Test – t-test for Equality of Means has been applied. For comparison of a few independent samples, Factor Dispersal Analysis (ANOVA) (One –Way Anova) has been applied. The SSPS statistics batch is used as an instrument for data processing.

RESEARCH RESULTS

The ability of respondents to use information technologies

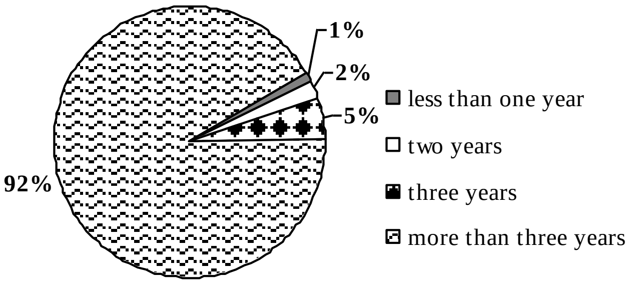

Figure 1. Duration of using the computer

The great majority of respondents (195/92.4 %) have been using computer for more than three years, nearly 1 %- for less than one year and over 6 %- for two or three years (Figure 1). Thus, the youth starting their studies at university have adequate experience and excellent opportunities for using computer technologies.

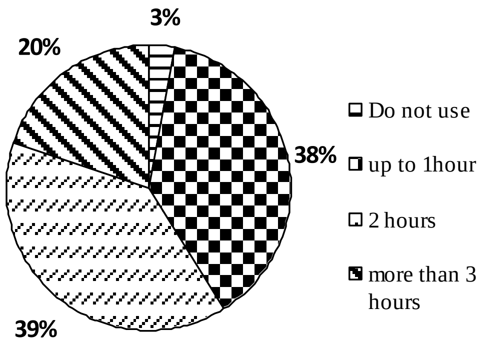

Figure 2. Duration (time) of using the computer for learning

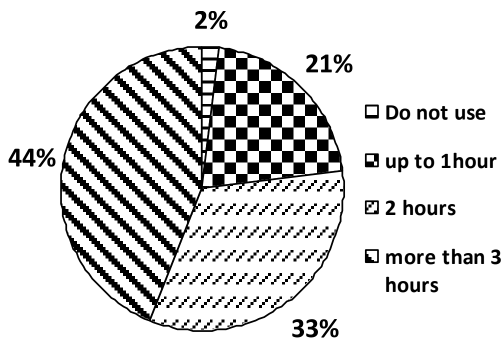

Figure 3. Leisure time at the computer

For learning 82/38.9 % I-st year SU students allot 2 hours, 81/38.4 %- up to 1hour and 42/19.9 %- more than 3 hours (Figure 2). 6 respondents (2.8 %) do not use computer while learning. We can assert, that modern computer technologies are actively used in teaching/learning process and computer itself is also a motivating means of learning. If students really allot 2 or 3 hours for learning every day it is likely that they will master subjects well and they will be ready for further career.

However, respondents allot even more time at the computer for leisure. 91/43.1 % of respondents spend more than 3 hours, 70/33.2 % allot 2 hours for this, 45/21.3 % -1 hour and only 5/2.4 % do not spend their leisure time at the computer at all (Figure 3).

Having analysed students' answers on computer literacy, it has been stated, that after graduation from comprehensive schools students possess quite good computer skills. They are able to change the font size, colour and style (AI = 0.93, SD = 0.14); to conduct the commands of coppying, cutting, deleting *(copy/paste, cut/ paste, delete)* (AI = 0.93, SD = 0.15), *to operate programme windows: to open them, to minimize, to close, to stretch* (AI = 0.92, SD = 0.16) and other. However, they lack specific knowledge for conducting more complicated operations, such as: bitmap and vector graphic software *(MS Paints, Adobe Photoshop, GIMP, CorelDraw, Adobellustrator* (AI = 0.43, SD = 0.26), *to create websites, to use website creation programmes (MsFrontpage, Macromedia Dreamweavery)* (AI = 0.25, SD = 0.26).

Seeking to decrease the number of variables without loosing the essential information, factor analysis employing the method of the main components with Varimax rotation has been carried out on 30 statements. 30 answers to one question were grouped considering six factors (Table 2). Taking into account general features these factors were named as follows: *More complicated functions of operating systems* (8 statements), *Basic operating systems and technical functions* (8 statements), *Special editing functions* (4 statements), *Work with files and computer equipment* (5 statements), *Elementary editing functions* (3 statements), *Internet, e-mail* (2 statements).

Table 2. The results of factor analysis of the ability of using computer and computer – based software

	FACTOR 1 *More complicated operating system functions*	**Factor loadings**	**Ability index (AI)**	
			Statement	**Factor**
1.	Make changes in programme settings	0.80	0.53	0.53
2.	Create websites, use website creation programmes (MsFrontpage, Macromedia Dreamweavery)	0.74	0.25	
3.	Install computer equipment drivers	0.72	0.56	
4.	Use file archiving programmes	0.72	0.54	
5.	Change systemic operating system parameters (sound, view, regional, keyboard language, computer clock)	0.69	0.69	
6.	Install programmes	0.68	0.66	
7.	Use bitmap and vector graphic software (MS Paints, Adobe Photoshop, GIMP, CorelDraw, Adobellustrator)	0.65	0.43	
8.	Know the main computer terms:bit, byte, megabyte, RAM, ROM, BIOS, HTTP, FTP, IP, RGB	0.62	0.60	
	FACTOR 2 *Basic operating systems and technical functions*	**Factor loadings**	**Statement**	**Factor**
1.	Operate programme windows: open them, minimize, close, stretch	0.70	0.91	0.87
2.	Use the main Windows OS graphic environment elements: desktop, browser (Windows Explorer), recycle bin, start button, taskbar.	0.68	0.87	
3.	Use mouse context menu	0.62	0.83	
4.	Use data storage equipment: compact discs (CD-ROM), usb stick (insert, remove, set and record data, formate)	0.62	0.87	
5.	Start programmes and documents	0.60	0.91	
6.	Correctly turn on and turn off the computer	0.59	0.95	
7.	Use computer input equipment (all letter number and function keys	0.51	0.88	
8.	Find files and folders in the hierarchic folder system	0.48	0.75	
	FACTOR 3 *Special editing functions*	**Factor loadings**	**Statement**	**Factor**
1.	Change the format of the paragraph: text alignment, line spacing, indentation, borders, background colour	0.74	0.79	0.77
2.	Change the printing page setup	0.72	0.76	
3.	Insert tables, number the lists,pictures and other more complicated objects	0.70	0.77	
4.	Check the spelling	0.68	0.75	
	FACTOR 4 *Work with the files and computer equipment*	**Factor loadings**	**Statement**	**Factor**
1.	Connect by wires the main external equipment with computer central processing unit: monitor, keyboard,mouse, speakers, microphone, printer	0.76	0.80	0.76
2.	Use file search system	0.62	0.79	
3.	Recognize the main file formats: exe, doc, txt, html, gif, jpg, mpg, mp3, zip, rar	0.59	0.75	
4.	Use Help system	0.54	0.65	
5.	Create file shortcut	0.51	0.80	
	FACTOR 5 *Elementary editing functions*	**Factor loadings**	**Statement**	**Factor**
1.	Conduct text copying and cutting,deleting commands (copy/paste, cut/ paste, delete)	0.77	0.92	0.92
2.	Change font size , colour and style	0.74	0.93	
3.	Conduct the main functions with files and folders: create, delete, copy, move, rename	0.74	0.91	

	FACTOR 6 ***Internet, e-mail***	Factor loadings	Statement	Factor
1.	Use the main internet browser functions: open the required page, download the files, find reviewed pages and so on.	0.71	0.85	0.87
2.	Use the main e-mail functions: read the received e-mail,create a new mail, send, forward, reply to the sender and so on.	0.62	0.88	

Ability index was calculated for every factor (AI). The obtained result shows, that the fifth factor has the strongest expression (AI = 0.92). Respondents are able to conduct elementary editing functions, such as: copy, paste, delete, change the font size, style and other the best. They also successfully use contemporary knowledge gathering and communication tools, such as internet and e-mail (AI = 0.87). Students are familiar with basic operating systems and technical functions (factor 2, AI = 0.87). The majority can operate programme windows (*open them, minimize, close, stretch*), use data storage equipment: compact discs (CD-ROM), usb stick (*insert, remove, set, record data, formate*), use computer input equipment (all letter, number and function keys) an so on.

The first factor- *More complicated operating system functions* (AI = 0.53) has the weakest expression. It is not easy to learn independently to create websites, change programme settings or install them. This can be learnt at school during informatics lessons, however they are not compulsory for senior class students.

Because of the fact that majority of students spend about 5 hours on avarage at the computer, the question arises whether the ability to use computer and computer software depends on the time spent at it. The carried out statistical analysis showed that computer knowledge and abilities do not depend upon the average of time spent daily at the computer for learning. However, a statistically significant deviation between time spent at the computer for leisure and the ability to use computer and computer programmes has been obtained. Those respondents who spend more than 3hours of their leisure time at the computer (AI = 0.63) are able to use More complicated operating system functions better (Factor 1), comparing to those who spend 2 and less hours (AI = 0.45). The null hypothesis about equal averages is rejected at the level of significance and makes $p < 0,0001$ ($F = 10.269$, $df = 3$). Students, spending more their leisure time at the computer, work better with files and computer equipment (AI = 0.85 compared with AI = 0.66, $p < 0.0001$, $F = 12.726$, $df = 3$); Factor 4). There is no statistically significant variation on other factors. We can think that students could learn independently things they were not taught at school, that leisure time at the computer is not only games but improvement as well.

Having carried out analysis in terms of schools, no significant deviations have been noticed.This shows that there are equal opportunities for regional students and for students from the city to acquire the basic knowledge of computer literacy.

A statistically significant deviation in terms of sexes has been obtained on the first, second and fourth factors. The null hypothesis H_0 about equal averages is rejected at the level of significance and makes $p < 0.001$.

Male students can operate more complicated operating system functions(AI = 0.72) significantly better ($t = -9.244$, $df = 209$), than female students (AI = 0.45). Male students can also use basic operating systems and technical functions better than female students (male students AI = 0.92, female students AI = 0.85; t = -3.551, df = 209). Male students succeed in working with files and computer equipment better (AI = 0.86), than female students (AI = 0.70; t = -6.260, df = 209). Other computer literacy knowledge (factors 3, 5 and 6) both of male students and female students is the same. (statistically no significant deviation has been noticed).

Analyzing the answers of the respondents distributed according to specialities: social sciences (SO) and physical, biomedical sciences (FB), statistically significant deviation on the first and on the fourth factor has been obtained. The null hypothesis about equal averages is rejected at the level of significance and makes $p < 0.001$. FB speciality students (AI = 0.61) are able to use more complicated operating systems better (t = -4.246, df = 209), than SO students (AI = 0.46). Also, FB students work better with files and computer equipment (FB students AI = 0.82, SO students AI = 0.70; t = -3.851, df = 209). Such result has been expected because among FB students there is a part of students,having chosen to study informatics and other specialities where deep knowledge of informatics is necessary.

Respondents ’computer literacy acquiring ways

The respondents‘ knowledge of using computer was assessed. The obtained results are presented in Table 3. The popularity index ($0 \le PI \le 1$) and standard deviation were calculated.

Table 3 shows that individual knowledge (PI = 0.84, standard deviation SD = 0.21) as well as friends, family members etc. (PI = 0. 72, SD = 0. 27) most frequently helped the students with using computer. A part of students found important knowledge and skills gained during informatics lessons (PI = 0. 63, SD = 0. 28). However, only a minor part of the respondents improved their knowledge and skills during the lessons of other subjects and extracurricular activities.

Table 3. Gained knowledge of using computer

	Ways of learning	N	PI	SD
1.	Independently	211	0.84	0.21
2.	Helped friends, family members etc.	211	0.72	0.27
3.	During informatics lessons	211	0.63	0.28
4.	During the lessons of other subjects	211	0.40	0.26
5.	During extracurricular activities	211	0.39	0.29

Forming two groups of respondents considering their specialities revealed (social sciences (SS) and physical/biomedical sciences (FBS) that taking into account all 5 parameters, no statistical significant deviation between the opinions of the students representing these groups was noticed.

A statistically significant deviation between the opinions of the graduates from city and regional centre schools was established in view of the impact of informatics lessons on improving knowledge about using computer. The null hypothesis about equal averages is rejected considering the level of significance which is $p < 0.001$. Informatics lessons had a higher impact on knowledge (t = -4.655, df = 209) of the students from regional centres (PI = 0.70) rather than on those from the city (PI = 0.53).

An assessment in terms of the sex indicates that female students learn better during informatics lessons than male students (t = -4.020, df = 209), respectively (PI = 0.68) and (PI = 0.51). Female rather than male students were also stronger influenced by other people (t = -3.736, df = 209), respectively (PI =0.77) and (PI =0.62). The null hypothesis about equal averages is rejected and the level of significance is $p < 0.001$. Though both male and female students in the majority of cases learnt to use computer independently, however, female students seem to be more straightforward and receptive to informatics lessons and help from other people.

Using computer-based technologies during the lessons of natural sciences

An assessment of the frequency of applying computer-based technologies during the classes of sciences (physics, biology, chemistry, geography) disclosed they had been used very rarely. The teachers relatively frequently used computer presenting new material during physics (PI = 0.30) and biology (PI = 0.23) lessons. Also interactive demonstrations were organized during physics (PI = 0.31) and biology (PI = 0.22) lessons. At times, the students self-sufficiently did homework and tasks on biology (PI = 0. 23) and physics (PI = 0. 20). Computer-based technologies were hardly applied during chemistry and geography lessons. It should be noticed that the teachers of sciences have a contact with students very rarely outside the classroom, i.e. give advice and prepare different tasks using appropriate software. No statistical deviation has been established between the answers of male and female students from the city and regional centre about the frequency of using computer-based technologies in the classroom.

Respondents' opinion about using computer-based technologies at school learning natural sciences

An assessment of opinions on applying computer-based technologies during the classes of sciences at school and the impact of computer-based technologies on personal development has been undertaken. The following statements can be regarded as the most relevant: *Using appropriate software made the process of learning more interesting during lessons* (PI = 0.79); *Computer-based technologies used by teachers made the lesson more engaging* (PI = 0.76).

However, the respondents have doubts about: *Using computer-based technologies in the classroom for the purpose of raising individual motivation* (PI = 0,50); *Using computer-based technologies in the classroom for the purpose of raising interest in sciences* (PI = 0, 47).

It is supposed that the respondents do not relate computer-based technologies to learning motivation and deeper interest in sciences as in comparison the teachers of sciences rarely apply computer-based technologies in the process of teaching. However, sciences in particular open up strong possibilities of using these technologies for educational purposes.

Factor analysis was carried out employing the method of the main components with Varimax rotation. 20 answers to this question were grouped considering three factors (Table 4). 6-7 statements describe each statement. Taking into account general features these factors were given the names *Interchangeable abilities, Negative impact of computer-based technologies* and *Cognitive abilities*.

Table 4. The results of factor analysis of using computer-based technologies

	FACTOR 1: *Interchangeable abilities*	**Factor loadings of items**
1.	Using software generated interest in the latest technologies	0.74
2.	Using computer-based technologies helped with choosing an individual method of learning.	0.74
3.	Using computer-based technologies in the classroom promoted communication between students	0.72
4.	Using computer-based technologies increased interest in sciences	0.65
5.	Using computer-based technologies helped with many-sided development of skills	0.64
6.	Using computer-based technologies helped with applying available knowledge in practice	0.64
7.	Using computer-based technologies in the classroom increased personal motivation for learning	0.63
	FACTOR 2: Negative impact of computer-based technologies	
1.	Using computer-based technologies distracted attention, prevented from intense concentration	0.80
2.	Using computer-based technologies prevented from continuous learning	0.78
3.	Using computer-based technologies in the classroom used to provoke stressful situations	0.73
4.	Using computer-based technologies has a negative impact on health	0.70
5.	Applying computer-based technologies in the classroom used to cause problems of communication with the teachers of sciences	0.68
6.	Using computer-based technologies in the classroom only increased dependence on them	0.67
7.	Using computer-based technologies has no impact on the process of learning	0.49
	FACTOR 3: *Cognitive abilities*	
1.	Computer-based technologies created possibilities of a better understanding of a new topic	0.77
2.	The applied software helped with a better acquisition of knowledge	0.77
3.	Lessons used to be more interesting when using computer-based technologies in the classroom	0.66
4.	Computer-based technologies created conditions of independent learning	0.65
5.	Lessons were not so tiring using computer-based technologies	0.63
6.	Using computer-based technologies in the classroom added more variety to the process of learning	0.62

The first factor *Interchangeable abilities* covered 7 statements describing the impact of IT on interest in sciences, technologies, motivation for learning, practical use as well as communication and collaboration between students. The second factor *Negative impact of computer-based technologies* embraced another 7 statements characterizing the impact of IT on concentration, consistent studying, stress removing etc. The third factor *Cognitive abilities* consists of 6 statements giving an account the impact of IT on learning a new topic, acquiring knowledge and making the process of learning more interesting. Every factor was given the popularity index (PI) (Table 5).

Table 5. The popularity indexes of factors

	N	PI	SD
Factor 1	211	0.57	0.18
Factor 2	211	0.31	0.17
Factor 3	211	0.71	0.15

Table 5 shows that the third factor has the strongest impact (PI = 0.71). The respondents accept that computer-based technologies have the highest impact on cognitive abilities, i.e. using computer helps with increasing the quality of learning. The obtained result PI = 0.31 of the second factor indicates that using IT in the classroom helps with concentration, prevents form distracting attention and does not create stressful situations, i.e. has no negative impact on the state of health and personal development. In terms of the first factor, slightly positive attitude exists (PI = 0.57). The respondents do not overemphasize the impact of computer-based technologies on motivation for learning, practical use as well as on communication and collaboration between students. A statistically significant deviation between the opinions of the respondents from the city and regional centre and the impact of computer-based technologies on the first factor *Interchangeable abilities* has been noticed. The null hypothesis about equal averages is rejected at the level of significance and makes $p < 0.001$. In terms of this aspect, the position of the surveyed participants from regional centres (PI = 0.60) is more positive ($t = -3.425$, $df = 209$) rather than of those from the city and makes (PI = 0.52). Therefore, it is supposed that the respondents from regional centres still want to use computer-based technologies more frequently than those from the city and therefore are more active in communicating and collaborating with their colleagues or are more engaged in sciences when using computer-based technologies.

Considering the opinions of the examined respondents in all factors, no statistical deviations between male and female students as well as between social and physical, biomedical sciences have been noticed.

DISCUSSION

It is without doubt, that modern computer technologies are actively used in teaching /learning process both in comprehensive and higher school. However, the question of their effective usage remains. It is also important that natural sciences require especially good quality visualization. Many schoolbooks, physical models and posters are outdated and no longer suitable for use, they do not display 3D or interactive objects (Bilbokaitė, 2009). On the other hand, students like working with computers, e.g., carry out different tasks, model things and so on. It is obvious that in natural science education the computer programmes are often used for modelling processes which cannot be demonstrated in real lessons (Myška, Kolar, Bilek, 2009). Moreover, various innovative teaching/learning platforms are being created, the applying of which in real educational practice will require appropriate computer literacy abilities from all education participants. As an example we can mention an Augmented Reality teaching /learning platform as an innovative technology aimed at implementing links between the real and virtual world. The technology developed by the

ARiSE project focuses on offering conditions for customers not only to observe a combined view (real and virtual) but also to directly interact with the real world (real objects) (Lamanauskas, Bilbokaite, 2009).

Therefore, technologies should not alienate from human being and reality. We should devote all our efforts to stimulating youth interest in science and technologies and to reinforcing scientific-technological education at all levels. Although hardly anyone suspects that technologies are having a growing impact on our daily life, however, they still remain alienated from the major part of society members and policy makers and what is more, frequently stand outside the door of the education system. We should discuss and try to solve all key problems really using the ICT in everyday school (and universities) activities (Lamanauskas, 2009). Our research showed that our I-st year students, virtually, are able to use computer technologies. They acquire these abilities not only at school, but from different other sources. Quite a big part of students can work with operating systems, which is, in fact, the function of a higher school. From this point of view, it is important to constantly observe the abilities of the youth coming to universities to use computer-based technologies and adequately renew study programs. E.g., the research showed that physical and biomedical science students are able to use computer-based technologies better than the students of social and humanitarian sciences. Undoubtedly, better preparation of Lithuanian comprehensive school teachers to use technologies in the teaching process has influence on this as well. For example, in 2006/2007 only 49 % of teachers were using ICT for teaching their subject. In 2008/2009 their part increased up to 67 % (Masaitis, 2009).

On the other hand, we have different students at school and at universities too. Their capabilities are so different. This means that modern teaching and learning combines different approaches. It is called “blended learning”. We also have to analyse the employment of different other technologies in the studying process. It is clear that little empirical reseach has been published on students` general use of technology in the context of Lithuanian higher education. The youth coming to universities use rather different technologies, e.g., computers, internet, mobile phones, e-mail and other. Hopefully, the more detailed and profound research will disclose up to now unnoticed things, which are very important in organizing the studying process. The research carried out in Australia showed that many first year students are highly tech-savy, however, when one moves beyond entrenched technologies and tools, the patterns of Access and use of a range of other technologies show considerable variation (Kennedy, Judd, Churchward, Krause, 2008). The authors hope that the more exhaustive research, started on the basis of this research, will help to uncover how students use in their studying process hardware and the Internet, computer based technologies, mobile phone based technologies, technology based tools, and web based technologies.

CONCLUSIONS

The results of the carried out research *Student and Computer-Based Technologies* has shown that:

- Computer knowlwdge and abilities do not depend on how much time on average daily computer is used for learning however, students spending more than three hours at the computer are able to conduct more complicated operating system functions and use more diverse programmes.
- It has been stated, that students are the best at conducting elementary editing functions,using internet and e-mail as a means of knowledge search and communication, operating programme windows,using data storage equipment, using computer input equipment and so on. The weakest point is creating websites, changing programme settings or installing them.
- It has been stated, that male students can use more complicated operating system functions significantly better than female students. Male students also succeed in using basic operating system and technical functions and working with files and computer equipment better than female students.
- In the majority of cases, the students learn to use computer independently, whereas next comes help provided by friends and family members. The lessons of informatics have a higher impact on the learners from regional centres and female students. The classes on other subjects and extracurricular activities have no significant impact on increasing knowledge of work at computer.
- It has been established that computer-based technologies are very rarely used during the lessons of other subjects. The teachers relatively frequently used computer during the lessons of physics and biology, les frequently - during the classes of chemistry and physics. The teachers of sciences very rarely use computer-based technologies outside the classroom, i.e. for tutoring, giving advice, performing different tasks.
- The respondents think that using computer-based technologies in the classroom during the lessons of sciences has the highest impact on cognitive abilities (knowledge acquisition, self-sufficient studies etc.). However, they do not find important the impact of technologies on motivation for learning, practical use, communication and collaboration between students. Moreover, applying computer-based technologies in the classroom helps with concentration, prevents from distracting attention and does not lead to stressful situations, i.e. has no negative impact on the state of health and personal development.

All these conclusions cannot be applied to the whole population, nevertheless they clearly show the general tendencies. Researchers can use the presented results for designing of more representative research.

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PROMOTING SCIENCE TEACHERS' ABILITY TO ADOPT USABLE ICT TOOLS IN PRACTICE: DESIGN OF A EUROPEAN TEACHER EDUCATION COURSE

Jari Lavonen

University of Helsinki, Finland

Heidi Krzywacki

University of Helsinki, Finland

Eric Sanchez

INRP, France

Valérie Fontanieu

INRP, France

Roger Erb

University of Education Schwaebisch Gmuend, Germany

Bernd Bühler

University of Education Schwaebisch Gmuend, Germany

Thomas Jurke

University of Education Schwaebisch Gmuend, Germany

Manuela Welzel-Breuer

University of Education Heidelberg, Germany

Sönke Graf

University of Education Heidelberg, Germany

Clemens Nagel

University of Vienna, Austria

Zhelyazka Raykova

Plovdiv University, Bulgaria

George Ioannidis

Patras University, Greece

ABSTRACT

Since adopting usable ICT tools to be used in science teaching and learning is still a challenge for teachers, there is a need to support teachers and enhance their potential regarding this matter. The prototype of an in-service teacher education course aimed at helping European science teachers to adopt usable ICT tools in their classrooms has been designed. In this paper, we discuss the problem analysis behind the design. In accordance with design-based research procedure, the first step was the theoretical analysis of the usability of ICT tools. Secondly, an international survey was conducted in order to clarify the needs and constraints of using ICT tools in science. Based on the survey, not only technical but also pedagogical usability should be introduced and discussed with the teachers during the course. Lastly, we discuss the course design from the perspective of problem analysis and the attempt to address the needs regarding ICT tools in science education.

Keywords: *ICT, usability, teacher education, design-based research*

INTRODUCTION

OECD (2006) has pointed out the increasing gap between the current use of Information and Communication Technology (ICT) for teaching and learning in schools and the daily experiences that pupils have with technologies outside of school. On the other hand, governments and other stakeholders in OECD countries have dedicated large budgets to ICT projects in schools. In science education several paradoxes can be recognised in the research literature considering the use of Information and Communication Technology (ICT) in science education (e.g. OECD, 2004; 2006; Lavonen, Lattu, Juuti, & Meisalo, 2006; Younie, 2006; Hayes, 2007; Hennessy et al., 2007):

- national level ICT-strategies, and national curriculum guidelines for ICT use have been prepared during the last two decades in several countries, but the influence on the visions and practice of the teachers regarding the use of ICT in education seems to be remote;
- there is research evidence of the influence that using ICT has on students' learning process and motivation, but teachers do not rely much on research-based evidence to identify good practices;
- students have rich experience in using technology outside the school context but not using technology for learning in school;
- science teachers are rather skilful in using technology, even if they are unable to make good use of their competence through applying ICT tools in their teaching;
- ICT is available at school, but science teachers' beliefs about teaching and learning, e.g., beliefs about good practice in school, do not support educational use of technology;
- plenty of teaching and learning material especially with a focus on using ICT in science education already exists (Osborne & Hennessy, 2003). However, science teachers are not experienced in using these materials effectively within regular classroom activities.

In general, there is a broad agreement about the reasons why ICT should be integrated into science education and the advantages of its use in teaching and learning science. The field of technology in education is seen to be important on the grounds of numerous specific web-pages[15] and associations for supporting use of ICT in science education. Despite active promotion of ICT use in education as part of educational policy and reform in science education, it is well known that change is either very slow or tends to fail. Implementation is a complex procedure, and it needs more than just a direct government policy to put it into practice (Younie, 2006; Lavonen, Juuti, Aksela & Meisalo, 2006). Consequently, it is a challenge to support science teachers in adopting the use of ICT as a part of their teaching in the classroom.

The project, Effective Use of Computer Aided Teaching and Learning in Science Education was launched together with six European countries in 2008. The aim is to design and to test various parts of an in-service teacher education course focusing on the adoption of versatile use of ICT in science education. In this paper, we focus on a particular course module concerning the issues related to choosing usable ICT tools for science teaching. However, because of the various educational traditions and teaching practices in different countries, designing a course to address the needs of European science teachers is as much a challenge as it is an enriching experience. The aim of this paper is to describe the theoretical and empirical problem analysis needed for designing the course, and thereafter, to discuss how these needs are to be taken into consideration in the course design.

DESIGN-BASED RESEARCH APPROACH FOR THE COURSE DESIGN

As a methodological framework for designing the teacher education course, we use the design-based research approach (DBR) that has been suggested as a solution for the discontinuation between educational research and praxis (Juuti & Lavonen, 2006). It is a general framework for design, development, implementation and evaluation of learning activities and it uses a pragmatic frame. DBR emphasises three aspects: (a) a design process is essentially iterative starting from the recognition of the need to change praxis, (b) it generates a widely usable artefact, like learning activities or a learning environment, (c) and it provides educational knowledge for more intelligible praxis (Design-Based Research Collective, 2003; Bell, Hoadley, & Linn, 2004).

15 http://www.york.ac.uk/org/seg/about_us/pages/ict_download_page.htm (The University of York Science Education Group) http://ict-in-science-education.wikispaces.com/ (Information Communication Technologies in Science Education)

DBR is comprised of the combination of theory development, the prescriptions of successful design processes, and the prescriptions of successful design solutions. The design procedure contains four main phases: 1) needs assessment; 2) theoretical problem analysis and definition of the objectives for a design solution, artefact; 3) design and production of the artefact; and 4) evaluation of the artefact.

OUTLINING THE POINT OF DEPARTURE FOR THE COURSE DESIGN

In this paper, we concentrate on describing the first two phases of the DBR procedure concerning needs assessment and theoretical perspective regarding ICT use in science education. The theoretical analysis illuminates existing challenges in the field in general, whereas the needs assessment focuses on what would be useful and needed from the point of view of the teachers representing especially six participating countries in the project.

THEORETICAL PROBLEM ANALYSIS

Theoretical problem analysis starts with a short description of the different ways of using ICT in science teaching and learning. Secondly, we will take a look at an adoption process of ICT use in science education. After the general review, we continue with a special focus on the aspects regarding the usability and versatile use of ICT tools in science learning activities. We have divided our review into two categories, technical and pedagogical usability, in order to clarify the knowledge of this complex and multifaceted area so as to be more applicable for our purposes.

The concept *ICT use in science education* is considered here as an innovation to be adopted by science teachers. We categorise ICT use here into *(A) tool applications or tool software* and *(B) ICT use in study and learning (learning through ICT)* (cf. Webb, 2002). In the *tool category (A)*, ICT is treated as a set of available software enabling students and teachers to accomplish their tasks in a more efficient way. Typical examples of tool software are related to school, course administration, or office software (text processing, spreadsheets, graphics, etc.).

Science teachers can use tool application in several ways. In addition to the previously mentioned, teachers can prepare assignments, tests, and other resources for teaching and learning. An LCD projector can be used as a tool for presentations in several ways and connected for example to a microscope. Furthermore, beside the rather traditional way of using ICT, an *interactive whiteboard* (White board, SMART Board) provides a new perspective for teaching and learning when promoting interaction and cooperative activities as well as dynamic use of ICT in the classroom. The touch-sensitive display connects the computer and digital projector, and therefore, computer applications can be controlled directly from the display, notes can be made with digital ink and the work can be saved and shared later on.

The main uses of *ICT in science studies and learning (B)* can be divided into three categories regarding direct support for learning: (i) Computer-assisted learning (CAL) is any interaction between a student and a computer system designed to help the student to learn. CAL includes, for example, simulations (Applets in the Internet) and virtual-reality environments; (ii) Computer-assisted research is the use of ICT as an aid in collecting information and data from various information sources with the emphasis on the use of ICT in supporting scientific reasoning. Typically, these investigative activities are conducted in small collaborative groups where ICT is used as an agent for interaction with the information source, like the Internet or nature through Microcomputer-Based Laboratories (MBL); (iii) Computer-assisted interaction: Open and distance learning (ODL) has evolved in a natural way from using only regular mail to using all available IT services adjusted to fully facilitate student learning. Thus, modern ODL solutions are based on a wide range of communication technologies, such as course management systems, for example Moodle, and two-way audio/video tele-conferencing. Nowadays, schools are more involved with ICT-based interaction channels. The Web 2.0 ideology is increasingly implemented for example through wiki and blog activities.

However, it is known that there are constraints: ICT use might be too complicated for beginners, science teachers do not easily collaborate with each other or with experts, they feel that they do not have enough time for experimenting, they might have negative attitudes towards innovations and the lack of motivation to adopt them, support available is not sufficient and, furthermore, people are doubtful about new ideas and innovations. Variables that influence the uses of ICT in science education are consistent with other research findings regarding innovations and diffusion or adaptation of innovations. The diffusion is a process by which the versatile uses of ICT in science education are communicated over a time period among the science teachers (social system) (cf. Rogers 2003). Rogers differentiates the adoption process from the diffusion process and defines the former as an individual's mental process through which he or she passes from first hearing about an innovation to final adoption. The adoption process can be divided into several stages, for example, as follows: awareness, interest, evaluation, trial, and adoption. Individuals who are members of the society adopting the innovation can be categorised into adopter categories: innovators, early adopters, early majority, late majority, and laggards (Rogers, 2003).

Fullan (2001) categorises the properties of educational innovations that affect their adoption in two general classes: Firstly, there are the properties of the innovation; in this case, the properties of the 'ICT use in science education' itself (e.g., different ways ICT use is practiced in TE, usability of ICT, and easiness of ICT use). However, the nature of this innovation is not simple. For example Watson (2001) argued that its adoption requires change in teaching style, change in learning approaches, and change in access of information. Secondly, Fullan (2001) emphasises that there are local characteristics, such as the pedagogical orientation of the science teachers, nature of collaboration and reflection between teachers, their beliefs about the usability of educational technology, administrative leadership, technical and pedagogical support available, and external factors such as funding, nature of training or staff development, as well as the nature of development projects in ICT use. Furthermore, external factors like a national ICT strategy and other different strategies in the institute have also an effect on the adaptation of the innovation. Different networks may foster the integration of ICT in education like collaboration between schools, and educational institutions, as well as connections with working life. The contextuality of the implementation is another important aspect in this research.

As discussed above, the ICT use involves both possibilities and challenges that teachers need to face in their practice. One perspective to promoting ICT use is to discuss the properties of an ICT tool approached here from the point of view of its usability. Usability of an artefact, in general, indicates to what extent people can employ an artefact in order to achieve a particular goal, i.e., the goals the designers of the artefact have been set as a goal for the use of the artefact. In human-computer interaction and computer science, usability usually refers to the elegance and clarity with which the interaction with a computer programme or a web site is designed (Nielsen, 1993). Nielsen has approached the concept of usability from the perspective of adoption and acceptability of an artefact. Following him, practical usability of an artefact could be defined through five quality components:

a) *learnability*, i.e., how easy it is for users to use a new artefact.
b) *efficiency*, i.e., how quickly a user can perform tasks (organise learning activities) once they have learned to use the artefact.
c) *memorability*, i.e., how easily a user could re-establish proficiency when returning to use the artefact.
d) *error-free*, i.e., how few errors users make when using the artefact.

e) *satisfaction*, i.e., how pleasant it is to use the artefact or how easy it is to change elements (avoidance of monotony) or modify the artefact individually.

Consequently, usability is a quality attribute concerning how easy it is for a user to accept or to start using the artefact. In the case of pedagogical innovations, it is appropriate to evaluate also pedagogical usability in addition to the technical usability dimension. Pedagogical usability of an ICT tool can be approached by analysing what kind of learning and development of motivation the use of the ICT tool creates. Motivation describes the factors within an individual which arouse, maintain and channel behaviour towards the aims of the learning activity and could be conceptualised based on the *Self-Determination Theory* (SDT) (Deci & Ryan, 2004). Central to SDT is the concept of basic psychological needs that are assumed to be innate and universal. These needs are the *need for autonomy*, the *need for competence*, and the *need for relatedness (need to belong to a group)*. Furthermore, the *interest* of the student in a learning activity can be added to these needs. Consequently, a pedagogically usable ICT tool could facilitate learning and increase the motivation of a learner in a learning activity.

In all, pedagogical usability of the ICT tool could be defined by six components through evaluating how the learning activity is supported:

a) *students' activity and intentions*: how students are guided to
   - take responsibility over their own learning
   - set goals (together with a teacher)
   - proceed according to the plan to reach the goals they set
   - plan by themselves or in small co-operative groups
b) *students' knowledge construction*: how students are guided to
   - combine their previous knowledge with the new topics to be learnt
   - tailor information structures that they can comprehend
c) *students' collaboration and interaction*: how students are guided to
   - actively take part in group activities and support each other by discussing and sharing knowledge
   - explaining, debating, and questioning
   - share ideas.
d) *students' self-evaluation and reflection*: how students are guided to
   - test their ideas
   - self-evaluating activities
   - examine their own learning (reflection)
   - develop meta-cognitive skills or skills which guide and regulate their learning?
e) *contextualisation of the learning environment*: how students are guided to
   - engage in learning in real life situations or in situations simulating real-life instances?
f) *student motivation*: have a positive effect on student's
   - feeling of autonomy, competence and social relatedness
   - interest in the content or a learning task
   - enjoyment or values

In Figure 1, we summarise the usability of an ICT tool. The main distinction here is pedagogical usability (Nielsen, 1993) versus technical usability. The former is in relation to the conventions of teaching a particular school subject, cultural constrains and affordances such as the pedagogical orientation of the teacher and beliefs about the usability of an ICT tool, administrative leadership and support, and external factors such as funding, in-service training, and collaborative partnership with outside organisations. The latter is related to technical aspects of the ICT tool, the possibilities opened up by using a particular ICT tool, i.e., what kinds of physical constrains and affordances the ICT tool has.

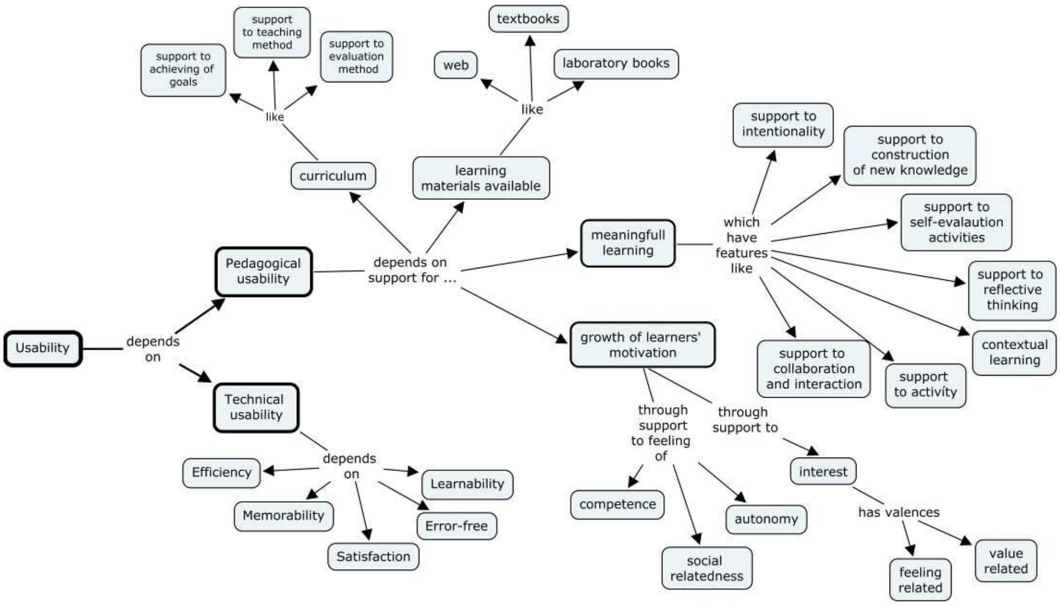

Figure 1. The usability of an ICT tool approached through pedagogical and technological aspects

As discussed above, usability of an ICT tool in education is a complex concept, and therefore, analysis should take into account the users of the ICT tool and their needs, the educational context regarding the curriculum, available learning materials, and implementation in the classroom, which we attempt to address in the following analysis of needs.

ANALYSIS OF NEEDS

In order to clarify the needs and constrains regarding the use of ICT in science education, an international survey within six participating countries (Austria, Bulgaria, Finland, France, German, Greece) was designed and carried out. The aim of the survey was to gain insights into the spectrum of possible conditions, needs and actual practices in using ICT in science classrooms, and to get the specific information needed to construct a teacher training course close to the conditions in schools in different European countries and their local contexts. Therefore, the questionnaire was aimed at three major groups: science teachers actively involved in science education, staff members involved with school management who are influential to the general infrastructure, and computer administrators responsible for the technical support in the schools. The needs and constraints stated by teachers regarding their teaching and in-service teacher education courses were our main interest. More than 50 teachers from each of the six partner countries, altogether 854 teachers, answered the survey. The results of the survey were presented and considered at the second project meeting in order to have a solid basis for creating the different course modules (Welzel-Breuer et al., 2009).

Here, we highlight a few themes brought up in the data that are especially interesting for the course module regarding the usability of an ICT tool. First, teachers tend to use ICT in their classroom with different intensity depending on nationality. Finnish and French participants informed that they integrate ICT use in their teaching often or daily, whereas Greek teachers stated that they are likely to use it seldom or never. In addition to the notion of various cultures of using ICT in daily schooling, difference between the sexes was in favour to men who used ICT more often. Second, confidence and competence of a teacher as a user of ICT in the classroom seem to be intertwined with each other. The feeling of being a competent user of ICT in science education was in relation with attitudes towards ICT use in general, i.e. the more confident the users regard themselves the more positive conceptions they have about benefits and added value of the use. According to the responses to the open questions of the survey, the possibilities to increase student interest and motivation in science learning, support students' autonomy or active learning were seen as the most positive features of using ICT in the classroom. Furthermore, it is rather natural that the teachers who have a competent view of themselves as users let their students use ICT in the classroom more often.

The survey was to gain also an insight into teachers' needs as users of ICT in their school work and they were asked to describe their needs regarding the professional development in ICT use. Teachers wished to get acquainted with some 'best practice examples', i.e. with ICT tools recommended by other users, and to have a chance to test provided tools and materials with the possibility to share experiences with their peers. It seemed also that they wished to have support for choosing ICT tools to be used in the classroom as well as to understand the basic principles of pedagogical decision-making. In addition to pedagogical issues, technical issues related to ICT use, for example difficulties in learnability, were mentioned as the most negative aspects in using ICT. Altogether, the need to be aware of various aspects of using ICT in a science classroom and to have support for choosing an appropriate tool for the classroom were brought up.

Since the teachers seem to have a need to build up readiness for using ICT in general as well as in science education particularly, we conclude that usability should be introduced for the teachers not only through technical but also through pedagogical aspects of usability. For example, technical usability of an ICT tool could be approached through quality components, like learnability. Furthermore, the issues related to learning and motivation should be considered in discussing pedagogical viewpoints. The aspects of confidence and competence are intertwined with each other, and therefore, the course needs to address both aspects.

DESIGN SOLUTION: AIMING AT ADDRESSING THE NEEDS IN THE FIELD

In this paper, we discuss the course module that aims at helping a science teacher to choose and adopt usable ICT tools for use in the classroom. In order to enhance this potential, the module comprises of four sub-modules which approach usability from different perspectives: (1) content related and technical usability, (2) usability especially in the case of multimedia, (3) pedagogical usability, and (4) motivational issues related to usability. The challenge in designing the course is to take into account the complexity of usability due to various related aspects. The structure of the module is not to cover all possible aspects but to provide a starting-point for approaching usability issues. The objectives of the course module are presented in Table 1.

Table 1. The objectives of the course module focusing on usability of ICT tools in science education

The overall aim of the module:
A teacher should be able to choose ICT tools for learning activities while taking usability into consideration in various ways.

Sub module 1. Content related and technical usability	*Sub module 2.* Usability of multimedia	*Sub module 3.* Pedagogical usability	*Sub module 4.* Motivational usability
A learner is familiar with and is able to take into account science content related and technical issues when selecting an ICT tool for a leaning activity.	A learner is familiar with and is able to take into account issues related to usability of multimedia when selecting an ICT tool for a leaning activity.	A learner is familiar with and is able to take into account learning related issues when selecting an ICT tool for a leaning activity.	A learner is familiar with and is able to take into account motivational issues when selecting an ICT tool for a leaning activity.
Contents in this sub-module are provided in two separate parts: *technical* and *content related usability*. A learner will - acquaint him or herself with issues related to technical and content related usability on the basis of research-based knowledge and literacy. Usability will be introduced through some main concepts regarding these two themes. -apply such knowledge in assessing some examples ('best practice examples' or the learner's own examples).	A learner will - acquaint him or herself with theoretical aspects regarding learning with media as part of teaching and learning science. Especially, a learner will be able to discuss learning theories special to the use of media, (like cognitive load, dual channel) - apply such knowledge in assessing some examples ('best practice examples' or the learner's own examples).	A learner will - acquaint him or herself with theoretical aspects regarding the learning process with ICT tools, students' activity and intentions, students' knowledge construction, students' collaboration and interaction, students' self-evaluation and reflection, and moreover diagnostic and formative evaluation contextualisation of the learning environment - apply such knowledge in analysis of particular examples of ICT use in science teaching and learning ('best practice examples).	A learner will - acquaint him or herself with theoretical aspects of motivation, for example with intrinsic and extrinsic motivation. In addition, a learner will get to know about basic psychological needs: need for autonomy, competence and social relatedness, and issues about what makes the topic interesting - learn about how to evaluate activity motivation by an inventory and to include motivating features in a learning activity

The overall aim of the course module is to provide activities for further professional development in two ways. First, the underlying idea is that a teacher should become aware of different perspectives of usability. For example, a teacher should acquaint him or herself with technical and content related issues, which can be seen to form criteria for assessing ICT tools available for science teaching and learning in the classroom. Since the usability and appropriateness of a particular ICT tool is related with the learning objectives in the classroom, the idea of usability is not to evaluate ICT tools as such. A teacher should become aware of the aspects according to which different tools and applications can be discussed. However, assessing and choosing the tools to be used in the classroom are always case-specific.

Second, since usability is something relative and dependent on the aims set for learning and the needs of a teacher, a teacher should be proficient in assessing and choosing ICT tools in general. The basic knowledge is not enough, and therefore ability to apply such knowledge in practice is needed as well. In the course module, the aim is not only to focus on basic information about usability but also to provide activities through which teachers can apply and integrate their knowledge in practice. The 'best practice examples' are to be discussed from various perspectives of usability. In that way, teachers get familiar with some new technological innovations, in accordance with their wishes stated in the survey, and even more importantly, they learn also how to apply their knowledge in various situations. The implementation of the course module includes both an e-learning phase and face-to-face meetings. In this way, the interactive and cooperative learning process includes discussions and possibly the sharing of experiences. Consequently, teachers attending the course can benefit from intercultural perspectives.

DISCUSSION

We have described the first phases of designing a teacher education course with the aim of enhancing science teachers' readiness for using ICT as part of their teaching. The focus of the paper was on the course module especially concerning usability and perspectives that a science teacher should take into account when choosing ICT tools to be used in the classroom. In accordance with the principles of design-based research (DBR), theoretical problem analysis and the need assessment of different actors have been carried out as the first step of the design process (see Design-Based Research Collective, 2003). In what follows, we discuss the course design reflecting on the needs and problems that are to be addressed.

First, various aspects associated with usability of ICT tools need to be taken into consideration when structuring the course module. We decided to concentrate on four subsets when considering usability. The idea was not to cover all possible aspects or design an overall framework of usability but to provide teachers with a starting-point for knowledge building using clear aspects which are relevant from the point of view of their work. The basic knowledge about usability can be considered as a way of enhancing professional readiness for pedagogical use of ICT tools. Even if a teacher is skilful in using ICT in general, for example for personal purposes, the pedagogical perspective needs a different orientation. Teachers need to gain some meta-level skills and knowledge about ICT use for educational purposes. Therefore, the module is to provide activities for applying the knowledge in practice as well.

Second, it is widely agreed that using ICT opens up new opportunities in teaching and learning science. Consequently, teachers need to commit themselves to professional development in order to be able to benefit from new opportunities and possibly renew their pedagogical views of science education. We do not claim that the way of teaching and learning science is to be changed totally, but so-called traditional methods need to be reconsidered. During the course, we would like to introduce to teachers some good examples and discuss conditions for their appropriate use through usability aspects. Teachers need to have good experiences of using ICT and positive ideas supported by experts in order to strengthen their feeling of competence.

Third, the challenge is to influence the attitudes that teachers have towards ICT tools as part of education. The critical point is whether a teacher integrates an innovation with classroom activities (Rogers, 2003). In the course module, motivation can be seen to be taken into consideration through three basic notions stated by Deci and Ryan (2004). The idea is to provide a solid basis for professional readiness including some knowledge and skills. In addition to the feeling of competence, teachers have an active role in the course and they are supposed to cooperate with each other.

Fourth, we have distinguished pedagogical and technical usability (Nielsen, 1993) to address the different needs indicated in the survey. In this way, teachers also become aware of different aspects that are essential in assessing usability. In addition, especially with the help of the module focusing on professional development, teachers will gain analytical tools for reflecting on their experiences and possible problems that they will face when using ICT in their classrooms.

Naturally, it is not possible to address all needs and problems that emerge in the initial analysis of the field. The course design is an attempt to face the various needs within the practical constraints. In the next phase of the developmental work, the course design will be partly tested and improved based on practical experiences and feedback. Different perspectives are needed to gain a broader insight, and therefore, teacher educators, teachers involved with testing the course material and researchers involved with the project are necessary in this process. Furthermore, since the course is for science teachers representing various European countries, intercultural perspectives and flexibility need to be considered as well.

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THE DISPOSITION TOWARDS CRITICAL THINKING AMONG RURAL SECONDARY STUDENTS OF SABAH, MALAYSIA

Yoon-Fah Lay

School of Education and Social Development,

Universiti Malaysia Sabah

layyoonfah@yahoo.com.my

Chwee-Hoon Khoo

Malaysian Teacher Education Institute – Kent Campus, Sabah, Malaysia

khoo8921@yahoo.com

ABSTRACT

Science curriculum in Malaysia gives conscious emphasis on the acquisition of scientific skills and thinking skills, the inculcation of scientific attitudes and noble values besides the acquisition of scientific and technological knowledge and its application to the natural phenomena and students' daily experiences. As pointed out by Renner and Philips (1980): 'The purpose which runs through and strengthens all other educational purposes– the common thread of education is the development of the ability to think'. The purpose of this study is to gauge the disposition towards critical thinking among Form 4 rural secondary students in the Interior Division of Sabah, Malaysia. This study is also aimed to ascertain if there is any significant difference in students' disposition towards critical thinking based on their gender and types of classes attended. This is a non-experimental quantitative research and sample survey method was used to collect data. Research samples were selected by using a two-stage cluster random sampling technique. The California Critical Thinking Disposition Inventory (CCTDI) was adopted to measure the key theoretical aspects of the overall dispositional dimension of critical thinking. The seven CCTDI scales measured were 'Truth-Seeking', 'Open-Mindedness', 'Analyticity', 'Systematicity', 'CT Self-Confidence', 'Inquisitiveness', and 'Maturity'. Independent samples *t*-test was used to test the stated null hypotheses at a specified significance level, alpha = .05. The research findings will bring some meaningful implications to those who are involved directly or indirectly in the development and implementation of science curriculum especially in the Interior Division of Sabah, Malaysia.

Keywords: *Disposition towards critical thinking*

BACKGROUND OF THE STUDY

Since education is a principal means of preparing students for an active and responsible life within a technologically-based society, school at all levels should become the focus for the fostering and development of critical thinking. According to Nelson (1994), "Enabling students to think critically is one of the central objectives of liberal and professional education." Critical thinking in education calls on students to evaluate their own thought process (Kalman, 2002). Critical thinking accompanies a movement in education toward inquiry-based or problem-based learning. According to Schamel and Ayres (1992), "students learn best by doing," or preparing their own questions based on their observations rather than participating in a "predetermined exercise with a forgone conclusion." Students are fully engaged in learning and cooperative group learning helps students interact with one another (Ahern-Rindell, 1998).

Hence, a current theme in science teaching reform is the emphasis on active, inquiry-based teaching and learning (National Research Council, 1996). Inquiry-based learning is a method of instruction focusing on the student and their ability to design a process for use in solving a problem, requiring higher levels of cognition. While inquiry-based learning takes the focus away from memorization of specific scientific concepts, there is supporting evidence that students learn as much “factual” information as they would in a traditional lecture/lab setting. However, inquiry students tend to retain the information longer and usually experience higher self-efficacy and process skills than students in traditional science courses. The case has been made for teaching critical thinking skills in school. Science classrooms provide many opportunities for inquiry-based or problem-based learning. However, in order for this inquiry-based learning to happen, changes must take place in science classrooms to move away from rote and passive application of learned formulas toward the use of critical thinking as the primary tool of learning (Zoller, Ben-Chaim, and Ron, 2000).

In consonance with the National Education Philosophy, science education in Malaysia nurtures a Science and Technology Culture by focusing on the development of individuals who are competitive, dynamic, robust and resilient and able to master scientific knowledge and technological competency. Hence, science curriculum in Malaysia gives conscious emphasis on the acquisition of scientific skills and thinking skills, the inculcation of scientific attitudes and noble values besides the acquisition of scientific and technological knowledge and its application to the natural phenomena and students’ daily experiences (Curriculum Development Centre, 2001).

Thinking is a mental process that requires an individual to integrate knowledge, skills and attitude in an effort to understand the environment. One of the objectives of the Malaysian national education system is to enhance the thinking ability of students. This objective can be achieved through a curriculum that emphasizes thoughtful learning. Teaching and learning that emphasizes thinking skills is a foundation for thoughtful learning. Thoughtful learning is achieved if students are actively involved in the teaching and learning process. Activities should be organized to provide opportunities for students to apply thinking skills in conceptualization, problem solving and decision-making (Curriculum Development Centre, 2001).

In Malaysian context, thinking skills are categorized into critical thinking skills and creative thinking skills. A person who thinks critically always evaluates an idea in a systematic manner before accepting it. On the other hand, a person who thinks creatively has a high level of imagination, is able to generate original and innovative ideas, and modify ideas and products. Thinking strategies are higher order thinking processes that involve various steps. Each step involves various critical and creative thinking skills. The ability to formulate thinking strategies is the ultimate aim of introducing thinking activities in the teaching and learning process (Curriculum Development Centre, 2001).

PROBLEM STATEMENT

Despite the emphasis on the acquisition of thinking skills among students, there have not been many well-documented research which aimed to gauge the disposition towards critical thinking among Form 4 rural secondary students especially in the Interior Division of Sabah, Malaysia. The possible differences in the disposition towards critical thinking based on students’ gender and types of classes attended have not been well-investigated and documented. Due to the scarcity of well-documented research in this field of study, this proposed study is aimed to gauge the disposition towards critical thinking among Form 4 rural secondary students and to determine if there is any significant difference in the disposition towards critical thinking based on students' gender and types of classes attended.

RESEARCH QUESTIONS

This study attempts to answer the following questions:-

i) What is the disposition towards critical thinking among Form 4 rural secondary students in the Interior Division of Sabah?

ii) Is there a significant difference in the disposition towards critical thinking based on students' gender?

iii) Is there a significant difference in the disposition towards critical thinking based on type of classes attended?

DEFINITION OF TERMS

Some of the terms used in study are defined as follows:

Terms	Definitions
Disposition	the attitudinal basis for the internal motivation to think critically. It is the tendency to do something or to have or develop something (Facione *et al*. 2000).
Critical thinking	the process of purposeful, self-regulatory judgment which involves cognitive skills as well as affective dispositions (Facione, 1990).
Truth-Seeking (the T-Scale)	targets the disposition of being courageous when asking questions, eager to seek best knowledge in a given context, and honest in the pursuit of inquiry even if the findings do not support one's interests or one's preconceived opinions. The truth-seeker would rather pursue the truth rather than win the argument. (Facione, 1990)
Open-Mindedness (the O-Scale)	targets the disposition of being open to and tolerant of the expression of divergent points of view with sensitivity to the possibility of one's own bias. The open-minded person respects the right of others to hold differing opinions. (Facione, 1990)
Analyticity (the A-Scale)	targets the disposition of being alert to potentially problematic situations, anticipating possible results or consequences, and prizing the application of reason and the use of evidence even the problem at hand turns out to be challenging or difficult. The analytically inclined person is alert to potential difficulties, either conceptual or behavioral, and consistently looks to anticipatory intervention, reason-giving and fact-finding as effective ways to resolve matters. (Facione, 1990)
Systematicity (the S-Scale)	targets the disposition toward organized, orderly, focused, and diligent inquiry. No particular kind of organization, e.g. linear or non-linear, is given priority on the CCTDI. The systematic person strives to approach specific issues, questions or problems in an orderly, focused, and diligent way, however, that might be accomplished. (Facione, 1990)
CT Self-Confidence (the C-Scale)	refers to the level of trust one places in one's own reasoning processes. CT self-confident persons trust themselves to make good judgments and believe that others trust them as well, since they believe others look to them to resolve problems, decide what to do, and bring reasonable closure to inquiry. (Facione, 1990)
Inquisitiveness (the I-Scale)	measures one's of intellectual curiosity. The inquisitive person is one who values being well-informed, wants to know how things work, and values learning even if the immediate payoff is not directly evident. (Facione, 1990)
Maturity (the M-scale)	targets how disposed a person is to make reflective judgments, particularly under conditions of uncertainty. The maturity scale addresses cognitive maturity and epistemic development. CCTDI scoring gives preference to those disposed to approach problems, inquiry, and decision making with a sense that some problems are ill-structured, some situations admit of more than one plausible option, and many times judgments must be made based on standards, contexts and evidence which preclude certainty. (Facione, 1990)

METHODOLOGY

Research Design

This is a non-experimental quantitative research. Non-experimental research is a systematic empirical inquiry in which the researcher does not have direct control of independent variables because their manifestations have already occurred or because they are inherently not manipulable. Hence, inferences about relations among variables are made, without direct intervention, from concomitant variation of independent and dependent variables (Johnson & Christensen, 2000). Sample survey method was used to collect data. In this study, the California Critical Thinking Disposition Inventory (CCTDI) was used to gauge students' disposition towards critical thinking.

Location of the Study

This study was conducted in 18 Form 4 classes of nine randomly-selected rural secondary schools in the Interior Division of Sabah, Malaysia. The distribution of schools and Form 4 classes according to four districts in the Interior Division of Sabah is shown in Table 1.

Table 1: Distribution of Schools and Form 4 Classes according to Four Districts in the Interior Division of Sabah, Malaysia

District	Number of Schools	Number of Form 4 Classes
Tambunan	2	4
Keningau	4	8
Tenom	2	4
Nabawan	1	2
Total	9	18

Research Samples and Sampling Method

The population of this study was Form 4 students from 22 rural secondary schools in the Interior Division of Sabah. The population size is approximately 3,500 students. The average age of the population is 16 years old. Sample size of this study was determined based on the formula suggested by Krejcie and Morgan (1970) and power analysis (Miles & Shevlin, 2001). Hence, sample size used in this study is considered adequate as compared to Krejcie and Morgan's recommendation which is a sample size of 346 for the population size of 3,500.

To be specific, a two-stage cluster random sampling technique was used to identify nine rural secondary schools and 18 Form 4 classes to be involved in this study. At stage one, systematic sampling technique was used to identify nine secondary schools from all the 22 secondary schools in the Interior Division of Sabah. After nine schools have been identified, simple random sampling technique was used to identify any two Form 4 classes from each of the chosen schools by using a random number table. All students in the chosen classes were automatically taken as the samples of the study. This combination of sampling techniques is to ensure the representativeness of the research samples.

Instrumentation

The California Critical Thinking Disposition Inventory (CCTDI) was adopted to gauge the disposition towards critical thinking among Form 4 rural secondary students in the Interior Division of Sabah, Malaysia. Each item on the CCTDI targets one of the seven dispositions toward CT i.e. Truth-Seeking, Open-Mindedness, Analyticity, Systematicity, CT Self-Confidence, Inquisitiveness, and Maturity.

CCTDI responses are registered using a forced-choice Likert scale that requires the respondent to either agree or disagree with each item. Respondents with a negative disposition toward CT earn 1, 2, or 3 points per item, while respondents with a positive disposition toward CT earn 4, 5 or 6 points per item. There is no middle choice. Hence, selecting the response consonant with a positive disposition toward CT will yield 4 or more points. However, selecting the response in opposition to that disposition will yield 3 points or less.

Each scale score is derived from the set of items that target that scale. For each item, there is a response, either "agree" or "disagree", conceptually associated with strength in the disposition that the item targets. Each scale addresses an individual and essential component of the critical thinker's habits of mind, and no individual disposition can be dismissed as less important to nurture. On the other hand, it should not be presumed that an individual who scores well on any given CCTDI scale can be predicted to have strong scores across all seven CCTDI scales. The Cronbach's alpha reliability coefficient of CCTDI used in this study was acceptable at 0.659.

Data Collection Procedures

Before administering the instrument, formal permission from the principals of the schools involved was sought and obtained. The California Critical Thinking Disposition Inventory (CCTDI) was administered by the researcher. In relation to this, students were gathered in the school hall and the instrument was administered to the students concurrently. The students were told about the nature of the instrument and how the instrument should be answered.

Data Analysis Procedures

Descriptive statistics were used to describe the disposition towards critical thinking among Form 4 rural secondary students in the Interior Division of Sabah. Among the descriptive statistics used were percentages, mean, average item mean, standard deviation, average item standard deviation and range. The CCTDI offers eight scores: the seven scale scores and the overall CCTDI total score. Each scale score ranges from 10 up to 60. In relation to this, the 'CCTDI Scale Standardization Table' was used to convert these item points into 10 to 60 point scale scores. Total possible scores range from 70 up to 420. The recommended cut score for each scale is 40 and the suggested target score is 50. Respondents who score above 50 on a scale are strong in that dispositional aspect. A scale score between 40 and 30 indicates ambivalence toward that disposition. Any score below 40 could be considered weak at best, since scoring below 40 requires responding to some items negatively. Respondents who score below 30 on a given scale are negatively disposed in that CT dispositional aspect. Scoring below 30 indicates that, on average, the respondent responds in opposition to the CT dispositional aspect measured by a given scale. An overall CCTDI score of less than 280 could be used as a cutoff indicator of overall deficiency in the disposition toward CT. Similarly, an overall score of 350 or more could be used as a general indication of across the board strength in the disposition toward CT.

On the other hand, as an effort to ensure all the quantitative data were drawn from a normally distributed population, graphical measures such as histogram, stem-and-leaf plot, normal Q-Q plot and detrended normal Q-Q plot were plotted for each of the variables studied. Furthermore, numerical measures such as skewness and kurtosis were used to identify any deviations from normal distributions (Hair, Anderson, Tatham, & Black, 1998; Miles & Shevlin, 2001). After the assumptions of using parametric techniques in analyzing quantitative data were met, independent-sample *t*-test was used to test the stated null hypotheses at a predetermined significance level, alpha = .05.

Independent Sample t-Test

Independent sample *t*-test was used to determine whether there is a significant difference in the disposition towards critical thinking between male and female Form 4 rural secondary students in the Interior Division of Sabah. The same statistical test was also used to ascertain the significant difference in the disposition towards critical thinking based on types of classes attended.

RESEARCH FINDINGS AND DISCUSSION

Students' Disposition towards Critical Thinking

Table 2 shows the mean and standard deviation of students' disposition towards critical thinking (overall and each of the seven subscales respectively).

Table 2: Mean and Standard Deviation of Students' Disposition towards Critical Thinking according to CCTDI Subscales

Subscales	Number of Items	*n*	Mean	Average item mean[a]	*SD*	Average Std. Dev.	Range
Truth-Seeking	12	402	41.46	3.455	6.39	.533	27-60
Open-Mindedness	12	394	49.38	4.115	5.55	.462	27-60
Analyticity	11	402	43.94	3.994	5.85	.532	21-59
Systematicity	11	403	47.46	4.314	6.31	.574	28-60
CT Self-Confidence	9	402	37.07	4.119	4.65	.517	22-49
Inquisitiveness	10	404	46.74	4.674	5.76	.576	25-60
Maturity	10	400	36.27	3.627	4.84	.484	21-53
Overall	75	370	302.91	4.038	20.14	.268	251-355

[a]Average item mean = Scale mean divided by the number of items in a scale

As shown in Table 2, the overall mean of disposition towards critical thinking (Mean = 302.91) indicated that students are ambivalently disposed towards critical thinking. Based on the mean value of each scale score, it can be concluded that students are positively disposed towards 'open-mindedness' (Mean = 49.38), 'systematicity' (Mean = 47.46), 'inquisitiveness' (Mean = 46.74), 'analyticity' (Mean = 43.94), and 'truth-seeking' (Mean = 41.46). However, students are ambivalently disposed towards 'CT self-confidence' (Mean = 37.07) and 'maturity' (Mean = 36.27). Based on the average item mean, the disposition towards critical thinking in descending order is 'inquisitiveness', 'systematicity', 'CT self-confidence', 'open-mindedness', 'analyticity', 'maturity' and 'truth-seeking'. Table 3 shows the percentages of students according to scale scores and overall scores of disposition towards critical thinking.

Table 3: Percentages of Students according to Scale Scores of Disposition towards Critical Thinking

Subscales	Nos. Items	*n*	Scale Scores		
			10-30 Negative Disposition	31-39 Ambivalent Disposition	40-60 Positive Disposition
Truth-Seeking	12	402	2.7	35.9	61.3
Open-Mindedness	12	394	.3	3.4	96.4
Analyticity	11	402	2.0	18.2	79.9
Systematicity	11	403	.5	10.9	88.6
CT Self-Confidence	9	402	8.0	61.8	30.2
Inquisitiveness	10	404	.2	12.6	87.1
Maturity	10	400	8.8	65.8	25.5
			Overall Scores		
			< 280 Negative Disposition	281-349 Ambivalent Disposition	350> Positive Disposition
Overall	75	370	13.8	85.4	.8

Mean Difference in the Disposition towards Critical Thinking between Male and Female Form 4 Rural Secondary Students in the Interior Division of Sabah

The first and second null hypotheses were tested by using the Independent sample *t*-test at a predetermined significance level, alpha = .05. As shown in Table 4, independent sample *t*-test results showed that there is no significant difference in the overall disposition towards critical thinking between male and female rural secondary students in the Interior Division of Sabah (t = -1.549, p = .122). In relation to this, female students are not more disposed towards critical thinking as compared to their counterparts.

Table 4: Mean Difference in the Disposition towards Critical Thinking based on Students' Gender

Subscales	Gender	*n*	Mean	*SD*	Mean Difference	Effect Size	*t*	*df*	*p*
Truth-Seeking	Male	123	41.27	6.436	-.27	-.04	-.389	400	.698
	Female	279	41.54	6.384					
	Overall	402	41.46	6.39					
Open-Mindedness	Male	125	48.56	5.696	-1.19	-.21	-1.996	392	.047
	Female	269	49.75	5.450					
	Overall	394	49.38	5.55					
Analyticity	Male	124	44.26	5.187	.46	.08	.775	276.040	.439
	Female	278	43.80	6.123					
	Overall	402	43.94	5.85					
Systematicity	Male	125	46.83	6.184	-.91	-.14	-1.339	401	.181
	Female	278	47.74	6.358					
	Overall	403	47.46	6.31					
CT Self-Confidence	Male	125	36.95	4.826	-.36	-.07	-.615	400	.539
	Female	277	37.31	5.572					
	Overall	402	37.20	5.35					
Inquisitiveness	Male	125	45.91	6.020	-1.19	-.21	-1.931	402	.054
	Female	279	47.10	5.605					
	Overall	404	46.74	5.76					
Maturity	Male	122	36.22	4.590	-.07	-.01	-.140	398	.889
	Female	278	36.29	4.960					
	Overall	400	36.27	4.84					
Overall	Male	114	300.48	20177	-3.51	-.17	-1.549	368	.122
	Female	256	303.99	20.069					
	Overall	370	302.91	20.14					

* $p < .05$

The effect size is the mean difference divided by the pooled standard deviation.

Table 5 shows the percentages of male and female students according to scale scores and overall scores of disposition towards critical thinking.

Table 5: Percentages of Male and Female Students according to Scale Scores and Overall Scores of Disposition towards Critical Thinking

CCTDI Subscales	Male			Female		
	10-30 Negative Disposition	31-39 Ambivalent Disposition	40-60 Positive Disposition	10-30 Negative Disposition	31-39 Ambilvalent Disposition	40-60 Positive Disposition
Truth-Seeking	2.4	40.7	56.9	2.9	33.8	63.3
Open-Mindedness	.8	3.3	95.9	0	3.4	96.6
Analyticity	0	13.9	86.1	.7	9.5	89.7
CT Self-Confidence	8.0	63.2	28.8	8.0	61.2	30.8
Inquisitiveness	.8	16.0	83.2	0	11.1	88.9
Maturity	9.0	68.9	22.1	8.6	64.4	27.0
	Male			Female		
	<280 Negative Disposition	281-349 Ambivalent Disposition	350> Positive Dispositon	<280 Negative Disposition	281-349 Ambivalent Disposition	350> Positive Disposition
Overall	15.8	82.5	1.8	12.9	86.7	.4

In relation to this, gender as a predictor of critical thinking skills or dispositions was a variable that has been evaluated by nearly all of the critical thinking studies. Wilson (1989) studied the critical thinking ability of entering college freshmen using the Watson-Glaser test and ACT College Reports. He found that gender was a significant predictor on critical thinking skill. Costa, McCrae's and Sanchez's study (as cited in Facione, Giancarlo *et al*. 1995) found that females were more open-minded and mature in their thinking, while males were more analytical. Walsh (1996) conducted a study of 499 male and female undergrads and found that gender was a predicting variable on the variance in critical thinking disposition. In a study of College of Agricultural and Life Sciences undergraduates at the University of Florida that evaluated learning style and critical thinking disposition, Rudd, Baker *et al*. (2000) found significant gender differences (alpha = .03) for scores of the CCTDI. However, there have been just as many studies indicating the null nature of gender effect on critical thinking. For example, in developing and validating an instrument to evaluate critical thinking skills of nurses, gender and ethnicity were found to be independent of critical thinking skills (Claytor 1997).

Hence, the role of gender has not been as conclusive. Some studies have shown gender to not be related to critical thinking skills (Claytor 1997), while other studies have found a significant relationship between gender and critical thinking skills (Rudd, Baker *et al*. 2000; Walsh 1996; Wilson 1989).

Mean Difference in the Disposition towards Critical Thinking between Science and Non-Science Form 4 Rural Secondary Students in the Interior Division of Sabah

Table 6: Mean Difference in the Disposition towards Critical Thinking based on Types of Classes Attended

Subscales	Types of Classes	*n*	Mean	*SD*	Mean Difference	Effect Size	*t*	*df*	*p*
Truth-Seeking	Science	198	42.35	6.420	1.81	.28	2.857	399	.004*
	Non-Science	203	40.54	6.243					
	Overall	401	41.46	6.39					
Open-Mindedness	Science	192	50.67	5.010	2.53	.46	4.633	391	.000*
	Non-Science	201	48.14	5.779					
	Overall	393	49.38	5.55					
Analyticity	Science	196	44.82	5.677	1.73	.30	2.976	399	.003*
	Non-Science	205	43.09	5.910					
	Overall	401	43.94	5.85					
Systematicity	Science	200	46.84	6.507	-1.21	-.19	-1.927	400	.055
	Non-Science	202	48.05	6.075					
	Overall	402	47.46	6.31					
CT Self-Confidence	Science	198	37.06	4.516	-.26	-.05	-.485	399	.628
	Non-Science	203	37.32	6.064					
	Overall	401	37.20	5.35					
Inquisitiveness	Science	198	46.83	5.788	.20	.03	.355	401	.723
	Non-Science	205	46.63	5.749					
	Overall	403	46.74	5.76					
Maturity	Science	199	36.54	5.056	.56	.12	1.161	397	.247
	Non-Science	200	35.98	4.620					
	Overall	399	36.27	4.84					
Overall	Science	177	305.80	20.478	5.69	.28	2.739	367	.006*
	Non-Science	192	300.11	19.450					
	Overall	369	302.91	20.14					

* $p < .05$

The effect size is the mean difference divided by the pooled standard deviation.

As shown in Table 6, independent sample *t*-test results showed that there is a significant difference in the disposition towards critical thinking between science and non-science rural secondary students in the Interior Division of Sabah ($t = 2.739$, $p = .006$). In relation to this, science students are more disposed towards critical thinking compared to their counterparts: 'truth-seeking' ($t = 2.857$, $p = .004$), 'open-mindedness' ($t = 4.633$, $p < .0005$), and 'analyticity'

(t = 2.976, p = .003). Hence, these findings had successfully rejected the second null hypothesis.

Table 7 shows the percentages of science and non-science students according to scale scores and overall scores of disposition towards critical thinking.

Table 7: Percentages of Science and Non-Science Students according to Scale Scores of Disposition towards Critical Thinking

CCTDI Subscales	Science			Non-Science		
	10-30 Negative Disposition	31-39 Ambivalent Disposition	40-60 Positive Disposition	10-30 Negative Disposition	31-39 Ambivalent Disposition	40-60 Positive Disposition
Truth-Seeking	.5	34.0	65.5	4.9	37.9	57.1
Open-Mindedness	0	0	100.0	.5	6.6	92.9
Analyticity	1.0	16.8	82.1	2.9	19.5	77.6
CT Self-Confidence	1.0	11.7	87.2	0	10.1	89.9
Inquisitiveness	7.1	65.2	27.8	8.9	58.9	32.2
Maturity	.5	12.1	87.4	0	13.2	86.8
	Science			Non-Science		
	<280 Negative Disposition	281-349 Ambivalent Disposition	350> Postive Disposition	<280 Negative Disposition	281-349 Ambivalent Disposition	350> Positive Disposition
Overall	15.8	82.5	1.8	12.9	86.7	.4

One of the possible explanations for this observation is that science students are given more opportunities and exposure to inquiry and problem-based learning as compared to non-science students. During inquiry-based learning, students are required to critically evaluate their own thought process in formulating a hypothesis, planning an experiment, collecting data, analyzing and interpreting data, and making a conclusion. Hence, the inquiry-based learning environment enhance students' disposition towards critical thinking.

CONCLUSION

Generally, this study found that Form 4 rural secondary students in the Interior Division of Sabah are ambivalently disposed towards critical thinking. Students are ambivalently disposed towards 'CT self-confidence' and 'maturity'. However, students are positively disposed towards 'open-mindedness', 'systematicity', 'inquisitiveness', 'analyticity', and 'truth-seeking'. This study also found a significant difference in the disposition toward critical thinking based on types of classes attended. Generally, science students are more disposed towards critical thinking than their counterparts in 'truth-seeking', 'open-mindedness', and 'analyticity'. However, the differences in the disposition towards 'systematicity', 'CT self-confidence', 'inquisitiveness', and 'maturity' are not statistically significant. Hence, those who are involved directly or indirectly in the planning and implementation of science curriculum need to plan effective intervention programs to enhance students' disposition towards critical thinking in an effort to improve rural secondary students' science achievement. These follow-up efforts are crucial to ensure that our nation's vision to establish a science and technology-based society will become reality.

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STUDENTS' ATTITUDES TOWARD THE ENVIRONMENT: THE RESULTS OF THE FRENCH SECONDARY SCHOOL STUDENTS SURVEY

Florence Le Hebel — ICAR/ ENS Lyon — florence.le-hebel@ens-lyon.fr

Pascale Montpied — ICAR/ ENS Lyon — Pascale.montpied@ens-lyon.fr

Valerie Fontanieu — INRP Lyon

ABSTRACT

The purpose of this study is to investigate the attitudes towards environment in the population of French students. We analyse the results of the questionnaire-based relevance of Science Education Project carried out in France in 2008 as a part of a wider international comparative study ROSE. The hierarchical ascendant classification of data from 2124 French students, led to three main classes, showing a high resonance, with the three main attitudes toward environment: egocentrism, anthropocentrism, and ecocentrism. The findings reveal significant gender effect in these three classes. Our data suggest that there are links between the three different attitudes toward environment and students' level of interest in learning about environmental topics. More, we could relate the three classes to the practice frequency of some specific out-of-school activities. Our data suggest that environmental attitudes are linked to environmentally-relevant behaviors.

***Keywords**: environment, attitudes, gender, ROSE project, , out-of-school activities*

BACKGROUND, FRAMEWORK AND PURPOSE

Science education has a key role in preparing young people to cope and to deal with responsibility emerging from environmental challenges.

Proposing two different views of Scientific Literacy, Roberts (2007) refers to the role of two legitimate but potentially conflicting curriculum sources: science subject matter itself, or situations in which science can legitimately be seen to play a role in other humans affairs. In this last perspective, environmental education is a key element of the scientific literacy, since it exemplifies science in context, in local environments and the daily life of people. Some argue that science education's role is to provide a set of skills and knowledge to be learned by students, who will decide themselves how to apply these competences, avoiding any risk of indoctrination. Others as for example Östman (2007) argue that science education needs to involve ethical as well as political reasoning. Failing to meet this challenge will mean that we run the risk of making students blind to the socialization to which they have been exposed. We will also miss the opportunity to make science education relevant.

As Jenkins (2002) and Layton et al. (1993) have shown, scientific knowledge will only become useful in everyday life when this knowledge interacts with economic, social and cultural aspects of life.

Developing students' knowledge and awareness of environmental issues has never been such an important goal of science education than now. But this teaching must be based on knowledge of students' attitudes to the environmental protection issue (Schreiner and Sjoberg, 2005). Diversity in humans' traditions, religious and spiritual approaches, philosophical directions may lead to different views of nature and environment, and consequently to diverse motivation and attitudes toward environment (Cooper & Palmer, 1998).

Environmental attitudes (EA) have been defined as « the collection of beliefs, affect, and behavioural intentions a person holds regarding environmentally related activities or issues » (Schultz et al., 2004). A pro-environmental attitude may result from different motivations that could have very different implications for behaviour and cognitive process. Several theories have categorized environmental values in similar ways : for instance, homocentric, ecocentric and egocentric values (Merchant, 1990) corresponding respectively to social-altruistic, biospheric and egoistic values according to Stern & Dietz (1994), and to anthropocentric versus ecocentric values (e.g. Thompson and Barton, 1994). The dimensionality of environmental attitudes and the nature of the dimensions are still discussed (e.g. Munoz et al., 2009).

The egocentric value is self-centred. It is based on an individual ought focused on individual good. It reflects the belief that what is good for the individual will benefit society.

Both ecocentric and anthropocentric individuals express positive attitudes toward environmental issues but not for the same reasons.

Anthropocentrics consider human to be the most important life form, and other forms of life to be important only to the extent that they affect humans or can be useful to humans. They feel that the environment should be protected because of its utilitarian value in maintaining or enhancing the quality of life for the largest number of people.

Ecocentric individuals assign intrinsic value to the whole environment, including animate and inanimate elements. The ecosystem intrinsic value is a sufficient reason for protecting it.

Our study takes place in an international survey project ROSE « Relevance of Science Education » developed by S. Sjoberg (http://www.ils.uio.no/english/rose). This project was designed to gather information about students' opinions of school science and science-related issues in general, including environment issues, and several other factors that have a bearing on their attitudes to science and technology and their motivation to learn science and technology. More than 40 countries are involved in this project, we led this international survey in France.

The main purpose of this study is to investigate the attitudes towards environment in the population of 15 year old French students. Do the French students feel interested and engaged in the environmental issues? What are the reasons of their involvement? Is there any link between French students' environmental attitudes and their interest to learn environment-related topics? May this engagement be linked to specific out-of-school activities?

METHODOLOGY

The questionnaire ROSE (downloadable from http://www.ils.uio.no/english/rose) written in English consists of 250 items, most of which are divided into 7 item groups : « my out-of-school experiences », « what I want to learn about », « my future job », « Me and the environment », « my science classes », « my opinions about science and technology » and « myself as a scientist ». For the French version, we added 43 background questions concerning home as well as questions concerning attitudes about taught sciences (mainly derived from the OECD Programme for Student Assessment PISA questionnaire) « Me and my strategy for learning Sciences », « Me and my family about technologies and Sciences », « Me and my confidence in my work in sciences ». The questionnaire mostly consists of closed questions with four-point Likert scale.

The ROSE target population in France was the cohort of 15 years old French pupils, living in our country in 2007. In order to obtain a sample representative of the disparities in French schools, the French Ministry of Education chose randomly 126 different schools in the data base, taking into account different criteria such as secondary school/high school (as repeating a year is common in France); Private/public, etc… All the schools did the questionnaire on line. The data were collected on a server using the software Modalisa. 104 schools answered and we obtained 2124 filled questionnaires. In our study, 51,7% of answers are from girls, 48,3% from boys. We applied statistical corrections to restore the statistical representativeness of the 104 responding schools.

In this present article, we focused mainly on students' answers to the questions about environment. Students were invited to indicate their degree of agreement using a four-point Likert-type scale to 18 statements about environmental problems.

Using the software SPAD (http://eng.spad.eu), we proceed to a hierarchical ascendant classification from factorial axes determined with a multiple factorial analysis according to Camiz and Pagès (2005).

RESULTS AND ANALYSIS

Table 1 presents the descriptive statistics summarizing the responses to the 18 statements relating to « Me and the environmental challenges ». French data are consistent with the international results showing a similar pattern of responses as in the other industrialized countries (Trumper, 2009). Those, compared to developing countries, have a lower level of concern for an involvement in environmental problems and interest in learning environmental topics.

Statement	Dis.	L. Dis.	L. Ag.	Agree	No op	Nil resp
1. Threats to environment are not my business	51,0	33,9	8,0	3,2	3,4	0,5
2. Environmental problems make the future of the world look bleak	11,1	25,3	36,6	16,3	8,9	1,8
3. Environmental problems are exaggerated	20,5	40,4	22,6	6,6	8,2	6,6
4. Science and technology can solve all environmental problems	17,4	43,7	20,8	7,0	9,5	1,6
5. I am willing to have environmental problems solved even if this means sacrificing many goods	6,2	13,6	47,8	23,1	8,1	1,2
6. I can personally influence what happens with the environment	12,1	22,3	39,9	13,4	11,3	1,1
7. We can still find solutions to our environmental problems	3,6	7,6	51,9	30,5	5,0	1,3
8. People worry too much about environmental problems	25,0	39,2	19,8	7,5	7,3	1,2
9. Environmental problems can be solved without big changes in our way of living	19,7	34,2	27,3	8,2	9,0	1,6
10. People should care more about protection of the environment	2,2	4,0	39,4	49,4	3,9	1,0
11. It is the responsibility of the rich countries to solve the environmental problems of the world	18,8	31,1	25,9	13,5	9,4	1,3
12. I think each of us can make a significant contribution to environmental protection	3,1	5,4	39,8	46,9	4,0	0,8
13. Environmental problems should be left to the experts	30,0	41,1	13,9	5,9	7,8	1,3
14. I am optimistic about the future	10,5	21,1	37,1	13,7	15,8	1,7
15. Animals should have the same right to life as people	12,1	19,8	30,3	21,7	15,3	0,9
16. It is right to use animals in medical experiments if this can save human lives	25,4	21,4	27,0	10,2	15,1	0,9
17. Nearly all human activity is damaging to the environment	8,3	29,8	34,7	13,4	12,1	1,6
18.The natural world is sacred and should be left in peace	3,4	8,0	39,1	39,1	9,6	1,0

Table 1 : Students' responses (in percentage) about environmental challenges (Dis= Disagree ; L. Dis. : Low Disagree ; L. Ag : Low Agree ; Ag : Agree)

As written above, we proceed to a hierarchical ascendant classification using the responses to the 18 statements about environmental problems. It led to four main classes. In Table 2, for some examples of the 18 statements relating to « Me and the environmental challenges », we reported modalities characterizing the three main classes 1, 2 and 3. We considered that a modality was a characteristical feature for a class when p-value (reported in table 2) < 0,001. For instance individuals in class 1, chose modalities reflecting lack of concern for environmental issues and a general belief that problems in this area have been exaggerated (statements 1, 3, 8 and 9). Most of the students in class 1 indicate a low degree of agreement to items describing a personal involvement (statements 5, 6, 10, 12). At the opposite, students in class 2 and 3 feel concerned about environmental issues and show a tendency to become involved and to make personal sacrifices. In table 3, we reported the percentages of negative and positive responses about environmental challenges for the three classes. The majority of the students in class 2 do not agree with the assertion that nearly all human activity is damaging to the environment (statement 17), and that animals have the same right to life as people (statement 15). The third class, express a high level of support for the animal life, even if it could save human lives in medical experiments (statements 15, 16). This third groups show the highest percentage of contributors to the notion of the natural world as something sacred that should be left in peace (statement 18). The fourth class correspond to students who answer "no opinion" for most of the 18 statements.

	Class 1 « egocentric »				Class 2 « anthropocentric »				Class 3 « ecocentric »			
	Dis.	L Dis.	L Ag.	Ag.	L Dis.	L Ag.	Ag.	No op.	Dis.	L. dis	L Ag.	Ag.
1		<0,001	<0,001	<0,001	<0,001				<0,001			
3			<0,001	<0,001	<0,001				<0,001			
5	<0,001	<0,001				<0,001						<0,001
6	<0,001	<0,001			0,038	<0,001					0,001	<0,001
8			<0,001	<0,001	<0,001				<0,001			
9			<0,001	<0,001	<0,001				<0,001			
10		<0,001	<0,001			<0,001						<0,001
12	0,001	<0,001	<0,001			<0,001						<0,001
13			<0,001	<0,001		<0,001			<0,001			
15	0,007	<0,001			<0,001			<0,001				<0,001
16		0,003	0,004	<0,001		<0,001		0,006	<0,001			
17		0,036				<0,001					<0,001	<0,001
18		<0,001			<0,001	<0,001						<0,001

Table 2: Repartition of the different modalities characterizing each class for different statements about environmental challenges. A modality is considered characteristic for a class when the p-value (reported above) < 0.001 (Dis= Disagree ; L. Dis. : Low Disagree ; L. Ag : Low Agree ; Ag : Agree)

Statement	Class 1 « egocentric »		Class 2 « anthropoc. »		Class 3 « ecocentric »	
	Neg.	Pos.	Neg.	Pos.	Neg.	Pos.
1. Threats to environment are not my business	63,53	32,28	93,71	4,60	95,15	3,90
2. Environmental problems make the future of the world look bleak	39,94	50,36	42,58	48,43	27,28	68,02
3. Environmental problems are exaggerated	31,21	63,41	67,02	23,79	91,42	15,47
4. Science and technology can solve all environmental problems	48,84	47,24	66,47	22,58	68,41	25,22
5. I am willing to have environmental problems solved even if this means sacrificing many goods	43,53	50,04	15,38	76,91	4,86	93,76
6. I can personally influence what happens with the environment	55,05	36,95	31,05	57,58	22,80	71,59
7. We can still find solutions to our environmental problems	25,12	71,94	5,29	91,82	4,55	91,91
8. People worry too much about environmental problems	28,38	64,97	71,01	22,90	89,51	9,42
9. Environmental problems can be solved without big changes in our way of living	39,57	56,34	56,70	37,30	65,97	29,74
10. People should care more about protection of the environment	16,65	79,96	1,49	96,73	0,65	98,61
11. It is the responsibility of the rich countries to solve the environmental problems of the world	39,97	56,55	59,52	35,26	49,81	44,35
12. I think each of us can make a significant contribution to environmental protection	24,58	72,10	2,34	96,17	1,21	98,61
13. Environmental problems should be left to the experts	36,21	59,07	81,18	10,85	96,55	4,61
14. I am optimistic about the future	27,39	62,08	27,37	53,84	40,84	47,71
15. Animals should have the same right to life as people	43,55	49,53	37,41	21,70	17,43	73,61
16. It is right to use animals in medical experiments if this can save human lives	42,15	50,4	39,39	42,48	60,69	28,50
17. Nearly all human activity is damaging to the environment	41,69	50,27	52,65	34,39	20,92	73,30
18. The natural world is sacred and should be left in peace	18,29	74,81	12,69	76,18	1,31	96,82

Table 3 : Students' responses (in percentage) about environmental challenges for the three different classes (Neg : negative ; Pos : positive)

Therefore, we suggest that the three main classes show respectively a high resonance with the three main attitudes toward environment egocentrism, anthropocentrism, ecocentrism. In table 4, we report the percentage of students in the different classes, and the proportion of girls and boys in each class.

egocentric		anthropocentric		ecocentric		No opinion	
23,8%		39,7%		30,1%		6,4%	
boys	girls	boys	girls	boys	girls	boys	girls
58,53	41,37	43,87	56,13	46,83	53,17	46,29	53,71
P value= 0.001		P value= 0.001		not significant		not significant	

Table 4: Percentage of students and boys/girls in the different classes, according to attitudes toward environment. The p value is indicated only when the gender effect is significant.

According to these results, there are more students showing anthropocentric attitudes toward environment in France than respectively ecocentric and egocentric attitudes. We can observe that there is a significant gender effect in two classes : the group reflecting an "egocentric" attitude including a majority of boys, and the group reflecting an « anthropocentric » attitude, including a majority of girls. These results are consistent with previous studies (Jenkins and Pell, 2006 ; Karpiack and Baril, 2008) revealing significant gender differences in attitudes toward the environment, particularly a lower contribution of girls in egocentrism than men. Nevertheless these studies show that women were higher in ecocentrism whereas our work does not reveal a significant gender effect in ecocentrism. We are aware of the limits of Rose questionnaire (number of questions) related to the concept of ecocentrism, anthropocentrism and egocentrism, using only a part of the scale developed by Thompson and Barton (1994) to measure these three attitudes toward environment.

More, we examined the students' responses according the three classes reflecting egocentric, anthropocentric and ecocentric attitudes in another section of Rose questionnaire. In this section, students were invited to indicate what they "want to learn about", by responding to a series of 108 diverse statements. Again, responses were made using a four-point Likert-type scale ranging, in this case, from "not interested" to "very interested", respectively scored as 1 and 4. The 108 statements include several ones related to environmental topics, as for instance, "the greenhouse effect and how it may be changed by humans » or « what can be done to ensure clean air and safe drinking water ». In table 5, we reported students' responses to the environmental–related topics according to the three main classes.

statement	*whole popul.*		*egocent.*		*anthrop.*		*ecocent.*		*chi2 test*
	neg	*pos*	*neg*	*pos*	*neg*	*pos*	*neg*	*pos*	
1. The ozone layer and how it may be affected by humans	45,9	48,9	61,1	35,0	45,6	50,2	30,8	66,4	0,000
2. The greenhouse effect and how it may be changed by humans	47,9	46,4	61,1	35,7	49,7	44,0	33,7	64,4	0,000
3. What can be done to ensure clean air and safe drinking water	31,8	63,3	47,8	47,0	30,1	66,6	17,5	80,7	0,000
4. How technology helps us to handle waste, garbage and sewage	48,7	46,4	57,1	40,6	51,1	44,3	37,4	59,9	0,000
5. How to protect endangered species of animals	31,8	63,4	34,2	62,5	23,6	73,0	7,1	92,2	0,000
6. Organic and ecological farming without use of pesticides and artificial fertilizers	54,8	37,9	65,7	29,7	57,7	34,0	40,2	55,6	0,000
7. How energy can be saved or used in a more effective way	35,1	59,3	46,7	50,1	35,9	59,0	20,7	76,8	0,000
8. New sources of energy from the sun, wind, tides, waves, etc.	36,3	57,8	45,8	47,5	38,3	57,0	23,1	74,5	0,000
9. Benefits and possible hazards of modern methods of farming	61,1	31,8	66,9	27,2	65,3	27,4	52,0	44,6	0,000
10. How people, animals, plants and the environment depend on each other	29,3	65,9	56,5	38,9	43,1	50,5	40,0	55,4	0,000

Table 5: Students' responses (in percentage) on what they want to learn about for the whole population and according to their environmental attitudes (respectively egocentrism, anthropocentrism and ecocentrism).

The results show links between students' attitudes toward environment, and their level of interest in learning about environmental topics. Particularly, ecocentric students express more concern than others in environmental topics. In another section of Rose questionnaire "my science class", students answered to what extent they agree with the statement "School science has increased my appreciation of nature". Students in the class reflecting ecocentric attitudes toward environment indicate a higher degree of agreement to this item (57,5% of positive answers) compared to those in egocentric class (36,0% of positive answers) and anthropocentric class (36,0% of positive answers). This link between school science and attitude toward environment has already been found in previous research (e.g. Karpiack and Baril, 2008), showing for instance that students who chose biology majors evidenced higher ecocentrism.

More, one section of the Rose questionnaire interrogates about out-of-school experiences. Students were invited to answer to the question « How often have you done this outside school? » by responding to a series of 61 diverse statements as “read a map to find my way”, “seen an X-ray as a part of my body”, “open a device to find out how it works” or “read my horoscope”. Again, responses were made using a four-point Likert-type scale ranging, in this case, from “never”, “rarely”, ”sometimes” to “often”, respectively scored as 1, 2, 3 and 4. In the table 6, summarizing examples of out-of-school activities according to the three different classes, we decided to preserve the poles « never » and « often ». Our data, reported in table 6, suggest that we can relate the three classes to the practise frequency of some out-of-school activities linked to nature, for instance « Collected different stones or shells », « Collected edible berries, fruits, mushrooms or plants » or « Read about nature or science in books or magazines ». Students reflecting ecocentric attitudes declare to practise more often out-of-school activities linked to nature than others.

These results are consistent with other works showing that students who feel concerned about environmental issues and showing a tendency to become involved and to make personal sacrifices, have environment view related to early life experience (e.g. Hutchison, 1998). Data in table 6, indicate as well environmentally-relevant behaviors, as for example «Sorted garbage for recycling or for appropriate disposal » or « Made compost of grass, leaves or garbage» are positively linked to ecocentric attitudes. This result is in agreement with previous research, indicating that ecocentrism is the only attitude that are predictive of environmentally friendly behavior (Thompson & Barton, 1994). In our study, the ecocentric attitude is only related to self-reported behavior and not to an observed behavior. We are aware of the limits of self-report measures of behavior, such as for instance, the desire to appear consistent with one’s expressed attitudes.

statement	***egocentric***		**anthropo.**		***ecocentric***		***chi2 test***
	never	*often*	*never*	*often*	*never*	*often*	
Tried to find the star constellations in the sky	53,1	9,5	40,6	9,2	32,7	16,3	0,000
Collected different stones or shells	23,0	14,5	8,5	19,4	7,5%	30,3	0,000
Watched (not on TV) an animal being born	46,2	12,0	58,1	5,6	45,1%	10,8	0,000
Cared for animals on a farm	46,8	12,9	43,9	9,1	35,4%	19,7	0,000
Visited a zoo	10,5	12,8	6,5	14,6	6,3%	22,3	0,000
Milked animals like cows, sheep or goats	57,7	7,0	67,0	3,2	61,7%	4,6	0,000
Read about nature or science in books or magazines	37,2	10,9	23,1	15,6	14,2%	25,4	0,000
Watched nature programmes on TV or in a cinema	31,4	14,1	16,9	12,1	10,2%	30,0	0,000
Collected edible berries, fruits, mushrooms or plants	29,9	17,0	19,9	19,2	15,9%	27,5	0,000
Participated in hunting	63,5	11,0	77,2	5,1	78,7%	6,8	0,000
Participated in fishing	33,5	17,8	35,5	12,0	35,0%	15,8	0,000
Planted seeds and watched them grow	38,0	10,9	32,4	8,6	25,0%	13,2	0,000
Made compost of grass, leaves or garbage	64,1	9,1	61,8	8,0	54,2%	13,2	0,011
Put up a tent or shelter	18,3	19,6	14,8	20,8	11,7%	25,7	0,000
Prepared food over a campfire, open fire or stove burner	32,2	18,5	30,5	19,1	29,6%	24,8	NS
Sorted garbage for recycling or for appropriate disposal	32,8	18,9	19,0	35,2%	11,4%	46,9	0,000
Taken herbal medecines or had alternative treatments	52,8	11,4	55,3	9,7%	46,6%	16,0	0,000

Table 6: Student's practice frequency of some out-of-school activities linked to nature according to their environmental attitudes (respectively egocentrism, anthropocentrism and ecocentrism). The responses are expressed in percentage. NS= Not significant

Finally, another section of Rose questionnaire, interrogates students about their future job. In this section, students were invited to indicate "how important are the following issues for their potential future occupation or job" by answering to a series of 26 statements, each with a 4-point Likert scale from "Not important" to "Very important". This question contains items meant to describe their priorities in different dimensions of their future work: Self-actualization, Work creatively, Leisure priorities, Care for surroundings, Power and glory, Dynamism and excitement, Fix and use hands and tools (Schreiner and Sjoberg, 2004). We found that students reflecting egocentric attitudes toward environment indicate significantly a higher degree of agreement to items related to Power and Glory as, for instance "earning lots of money", "controlling other people" or "becoming famous" than those expressing anthropocentric or ecocentric views. At the opposite, the latter answer more positively to the items related to Care for surrounding, as for instance "helping other people" classified as Benevolence in Schwartz value instrument (1994), or "Protecting the environment" classified as Universalism by Schwartz (1994) and Self-actualization items as "working with something that fits my attitudes" or "developing or improving my knowledge and abilities". We suggest that some of these results have a resonance with previous studies (Schultz & Zelezny, 1999), showing that ecocentric concerns were significantly related to universalism (positively) and power (negatively). One limitation of our study is that our work does not include the full scales of the Thompson and Barton ecocentrism-anthropocentrism measure (1994) and Schwartz's universal values scale (1994).

IMPLICATIONS

These different attitudes toward environment among the French students population reveal the importance of taking into account the diversity of these students' views in any program of environmental education. It may be important to consider for instance the ecocentric-anthropocentric distinction in the design of message to encourage environmental conserving behaviours. Indeed, students reflecting ecocentric or anthropocentric attitudes, who both support environmental issues but for different reasons, may respond to different appeals. We should encourage them to appreciate the different ways of thinking about environmental issues. According to the results, we need to consider as well the role structures other than school can play in enhancing interest in understanding of environmental problems and developing environmentally-relevant behaviours.

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PROJECT BASED LEARNING AND FIELD STUDY

Zaklin Luksa

Gimnazija, Čakovec, Croatia,
zaklinluksa@gmail.com

Ines Radanovic

Faculty of Science, Zagreb, Croatia

iradan@biol.pmf.hr

Diana Garasic

Agency for education, Zagreb, Croatia
Diana.Garasic@azoo.hr

Elma Keric

elma.keric@gmail.com

ABSTRACT

The goal of the research was to establish to what extent project based learning, especially field study influences the quality of acquired knowledge. The research was conducted on the sample of 64 sixth-grade primary school pupils, and 70 fifth-grade primary school pupils. Separately, on the sample of 40 primary school teachers the attitudes of teachers about field study were also surveyed. The fifth-graders were divided into experimental and control groups. The experimental group practised project based learning and field work, whereas classic frontal teaching methods were used with the control group. The data collection instruments used were three tests and two questionnaires. The surveys were conducted on fifth- and sixth-grade pupils. Testing results show the increased success of the pupils included in project-based learning, especially in field study. This may be related to the increased motivation of pupils when project-based learning and field study are applied, as shown by the survey results. Therefore, the results of the research confirm the need of project-based teaching and field study.

Keywords: *learning, field study, project-based teaching, active forms of teaching, motivation*

INTRODUCTION

The concept of learning in nature or field study is wide and versatile because it comprises various forms of field study according to its concept, goals, outputs, locations, the time required etc. (Rickinson et al., 2004; Scott and Gough, 2003). Most research shows the benefits of this form of teaching. In traditional classes pupils often do not have an opportunity to learn in an amusing way and based on experience. Therefore, too often the joy of learning is fading and students learn how not to learn (Dryden and Vos, 2001.). Teachers should also try to find ways how to motivate students to learn and enjoy in it at the same time. In a modern school a pupil should be an active participant in the teaching process (Jensen, 2003.). In pupil-oriented teaching, a pupils should be more active than a teacher (or at least as active), because a class in which pupils only sit, listen and look cannot satisfy their biological, social or creative needs, their curiosity and wish to act (Matijevic, 2008.). Field based learning is one of the ways of active inclusion of pupils into a learning and teaching process and according to the research (Martin et al, 1981; Bogner, 1998; Preston and Griffiths, 2004, Dillon et al, 2006) in such a way positively influences the development of all three domains of learning through the development of social competencies, knowledge acquisition and encouraging forming positive attitudes among pupils.

Field study encourages pupils' motivation. In the research, Rickinson et al. (2004) point out positive changes in application of field study on pupils' cognitive, affective and interpersonal competencies that are developed through various forms of field study. Some of the benefits of this kind of learning are better critical thinking abilities, better test results, greater enthusiasm and motivation for learning (Ballantyne and Packer, 2002; Lieberman and Hoody, 1998; Rickinson et al., 2004). Abrahams researched how practical work influences motivation and pupil's emotional commitment. The results of the research conducted on a sample of pupils aged from 11 to 16, showed that practical work motivate pupils to learning but their emotional commitment is short-lived and that long-term use of practical work in teaching will not contribute to more pupils to choose science subjects (Abrahams, 2009.).

The research points out a number of institutional, cultural or logistic hindrances that restrict field study outdoors (e.g.. Barker et al., 2003; Comishan et al., 2004; Fisher, 2001; Ham and Sewing, 1988; Hart and Nolan, 1999; McCutcheon and Swanson, 2001; Rickinson et al., 2004; Simmons, 1998). Rickinson at al. (2004) emphasise five key obstacles of outdoor learning: fear and care for pupils' health and safety, teacher's confidence in outdoor teaching and their professionalism in teaching (e.g. absence of pre-in-service teacher's training); unadapted curriculum (e.g. curriculum does not leave enough time for organising field study, the teaching method that do not prepare pupils for standardised tests etc.); lack of time, means and support (e.g. too much additional work for teachers, shortage of financial resources, transport and accommodation problems); support of wider educational system and supporting structures (e.g. size of class, field study limitations, emphasis on programme basis).

Rickinson points out that some of these hindrances might be solved by organising outdoor classrooms in a school yard and school surroundings because in such a way the costs are reduced as well as the time required for organising that kind of teaching (Rickinson et al., 2004.). Dyment research (2005.) showed that green schools grounds can reduce the hindrances of outdoor learning. Within the framework of formal curriculum, the examples from literature suggest that there are numerous subjects that might be taught outdoors in the school surroundings (Adams, 1990; Bell, 2001; Centar za Ecoliteracy, 1999; Cronin-Jones, 2000; Engel, 1991; Gamson Danks, 2000; Grant and Littlejohn, 2001; Hansen-Moller and Taylor, 1991; Lieberman and Hoody, 1998; Malone and Tranter, 2003; Olwig, 1991; Rhydden-Evans, 1993; Thomson and Arlidge, 2000). The authors who investigated the possibilities of field study in school surroundings agree with the fact that the learning context is changed, as well as pupils' motivation, pupils more easily make concepts and connect knowledge. Pupils have more opportunities to notice interconnectivity between education, their homes and everyday life.

GOAL OF RESEARCH

The goal of research was to establish to which extent the primary school students are included in field study, what their experiences with field study and project-based learning are as well as their attitudes about field study.

Another question was to establish how much active inclusion of pupils into a teaching process through projects and field study influences the quality of acquired knowledge and pupils' motivation for learning.

MATERIALS AND METHODS

The research was conducted during the school year 2006/2007on 68 six-grade pupils aged 12 – 13. The pupils were divided into an experimental (E) and a control group (C) with the pupils of two classes (47) in the experimental group, and the pupils of the third class (21) in the control group. At the beginning of the research all the pupils were tested (an initial test before the beginning of teaching the specific subject matter - test I) due to the need for establishing the initial state and comparison of students in groups E and C.

The experiment was conducted in the period in which Deciduous woods, a teaching unit divided into 7 smaller units was taught, during which the experimental group made two independent projects which included independent work outside school and at home.

In the first project (Project 1 – Visit to a deciduous forest) the pupils were divided into groups of 5. Each pupil got the instructions for conducting the project and its presentation. Their task was to visit a nearby forest and observe everything around them. They should use the material collected to make a poster with the topic Deciduous forest in 12 days. Upon the end of the project it had to be presented to the other pupils in their class. Each group got three marks that comprised creativity, usage of additional literature and presentations. In this way, we wanted to encourage the pupils to learn how to observe the world and nature around themselves. Competitive spirit as well as mutual cooperation was also supposed to be encouraged.

In the second project (Project 2 – Essay on the topic of protected animal species in a deciduous forest or an essay on the topic of medicinal plants in a deciduous forest) the pupils were divided into pairs. Each pupil was given instructions for conducting the project in the period of 14 days and the detailed instructions how to write an essay. The task was to find at least 3 selected species in literature learn about them in details. This project was intended to encourage the pupils to use additional literature, use the Internet as an educational means and show them how to write professional articles in the field of biology. Each pair got a collective mark which included the mark for creativity, text processing and a presentation. Teaching in class, not dependent on the projects, was adjusted to pupils. Pupils were put in the centre of attention, a teacher was only a leader of various active ways of learning. The pupils were taught how to work on the text, how to differentiate between what is more and less important and present the text in the form of bullet points convenient for learning. There were 3 different types of work on the text: make conclusions about the answer to the question asked in the worksheet and presentation of the answer to the rest of the class, summarise the text by extracting the bullet points, differentiate between the more and less important by using the two-coloured texts when making conclusions about the forest layers and mapping the knowledge and make a concept map and presentation to the rest of the class. Except for working on the text, the teaching unit called The tree layer in a deciduous forest was presented on the pupils' posters from the first project. The poster materials were used for teaching the pupils about the trees that can be found in a deciduous forest. The topics regarding the animal world, protection and exploitation of woods are also taught by means of mind maps, which proved as an efficient and simple solution. Revision was done through games.

Three tests were used as instruments for collecting data. At the beginning of the research all the pupils were tested for establishing the initial state and comparison of the pupils from E and C groups (initial test before the beginning of teaching of the specific subject matter – test I). After the first project had been finished, the pupils took test II. The test contained the questions from the course book and no questions connected with the project. We wanted to check if there was the difference in knowledge acquisition among the pupils depending on the fact if they worked on the project or they only attended regular classes at school. After the end of the second project the pupils took the second test which comprised the subject matter of the teaching unit Deciduous forest. The questions were exclusively connected to the subject matter from pupils' handbooks.After the experiment had been completed, the sixth-graders who participated in the research were surveyed with the purpose of collecting data on their own experience of teaching methods and application of projects.

The fifth-grade pupils did not participate in the described experiment, but they were polled in order to examine their attitudes towards project based learning and school in nature, based on the experiences during their education, since the fourth-grade curriculum prescribes a week of school in nature.

The results were analysed by the programmes EXCEL 2007, STATISTICA 8. Statistical significance was established based on ANOVA analysis, and for the presentation of interrelationship of results and variable connectivity measures, the Pearson's correlation coefficient. By linear regression model the trends of test results (success) were established. According to the previously published results of the research (Luksa et al, 2009) it was established that although logarithmic regression form explains pupils' results better, it is better to use a linear model to present the total test results success, since it still shows satisfactory reliability, but also diminishes the significance of rare successful individual test results.

RESULTS

By conducting initial testing (I. Test) of the pupils in both experimental (E) and control (C) groups (Figure 1.), statistical difference of results was not established, by which the balance between E and C groups in previous knowledge on deciduous trees was confirmed, which enables further comparison of the results during the research. Significant difference between individual results of the E and C groups during testing was not established, which points to the homogeneity of the pupils' results.

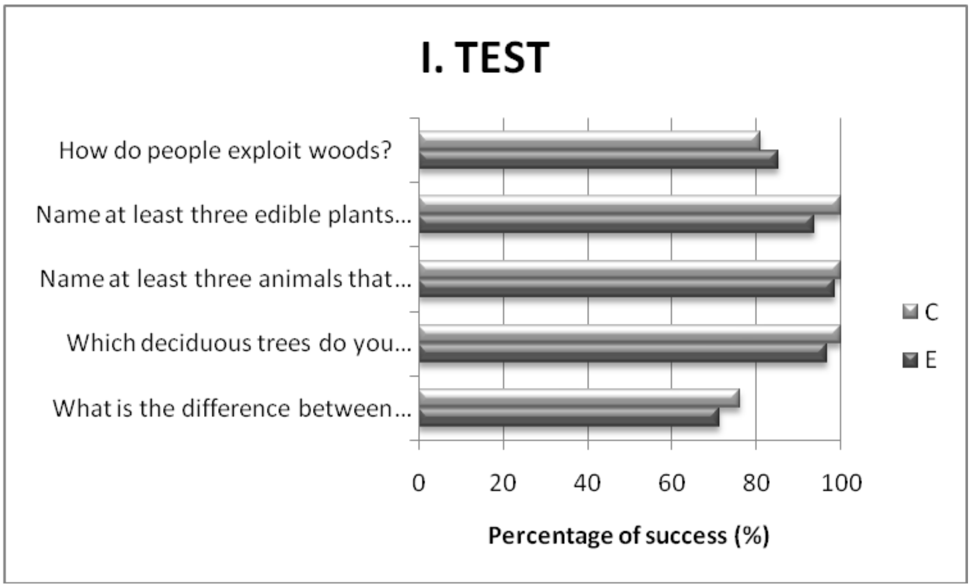

Figure 1. Results of the initial test of the experimental (E) and control(C) group

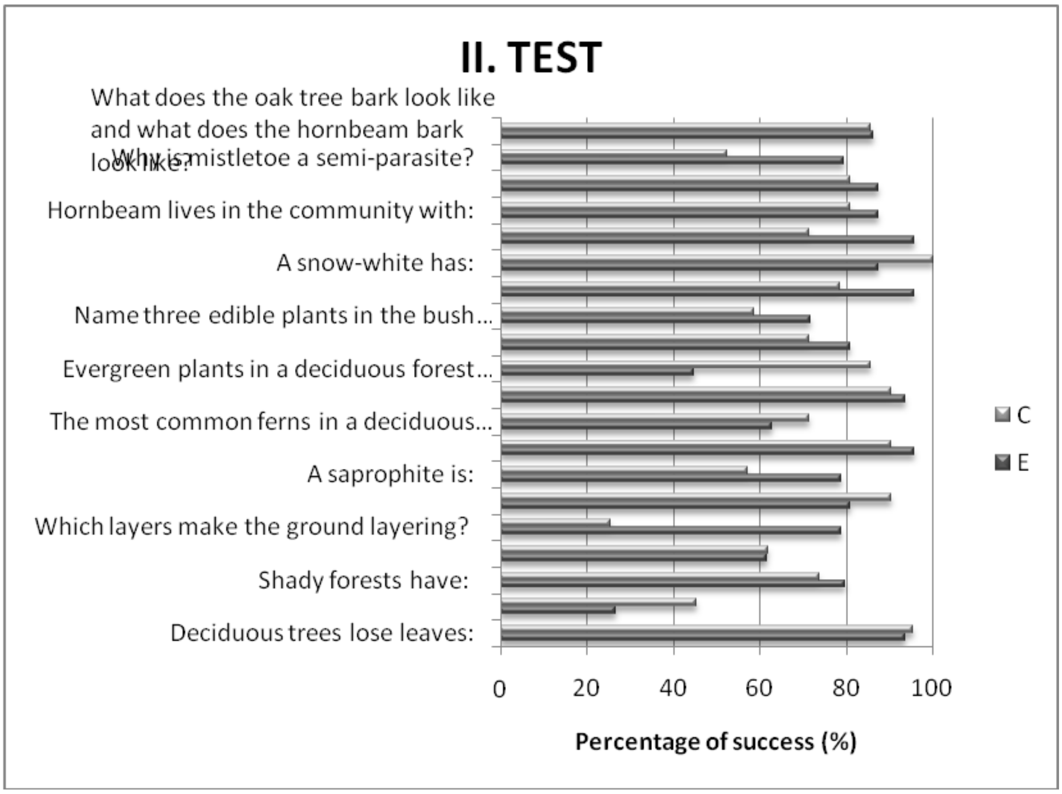

Figure 2. Results of Test II of the experimental (E) and control (C) group of pupils, before which the group E had worked on Project 1: Visit to a deciduous forest

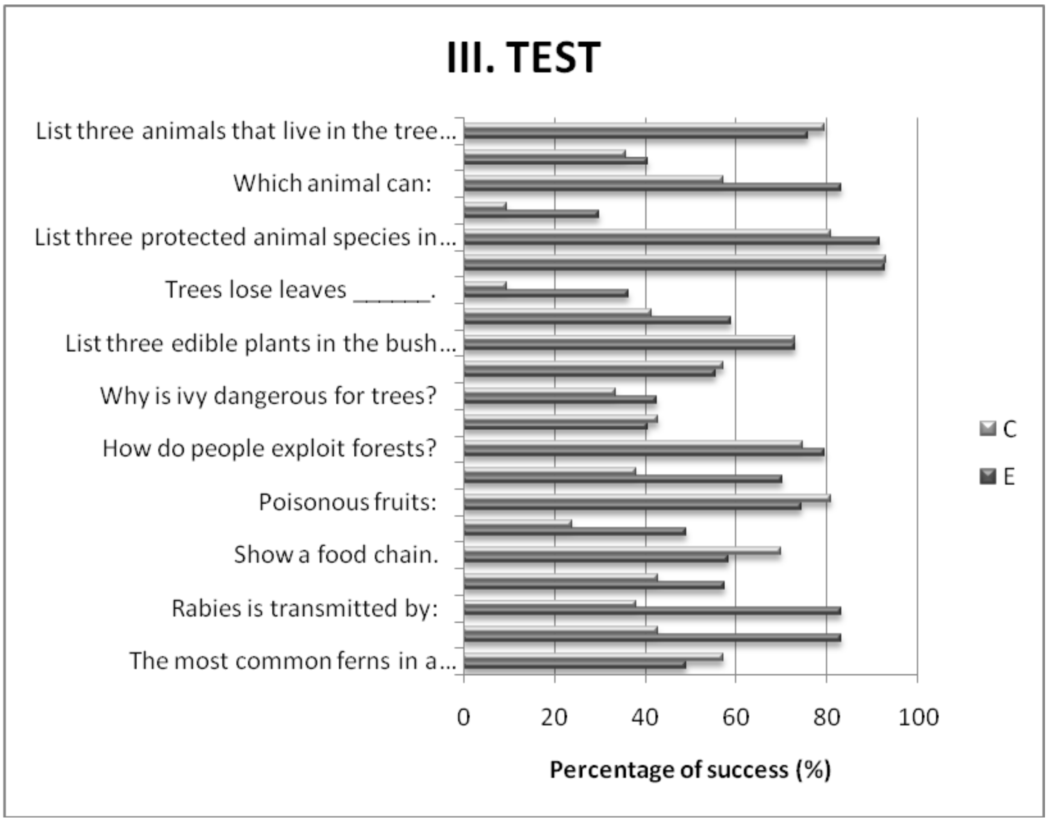

Figure 3. Results of test III of the experimental (E) and control (C) groups, before which the group E had worked on Project 2: Essay on the topic of Protected animal species in a deciduous forest or an essay on the topic of Medicinal plants in a deciduous forest

In Test II the results of group E were 65% better compared to group C (Figure 2). All the questions were connected to the contents which the pupils from group A additionally met during working on the project. In Test III the results of group E were 67% better compared to group C (Figure 3). Having analysed the questions that repeat in Tests II and III (Figure 4) the pupils included in the project work solved the test results were 15 to 27 % better than the results of the pupils from the control group. The answers to the question connected to the explanation why trees lose leaves, were done better in Test II by the C group pupils, but in Test III their success was 36% lower which indicates to more permanent knowledge of the E group pupils.

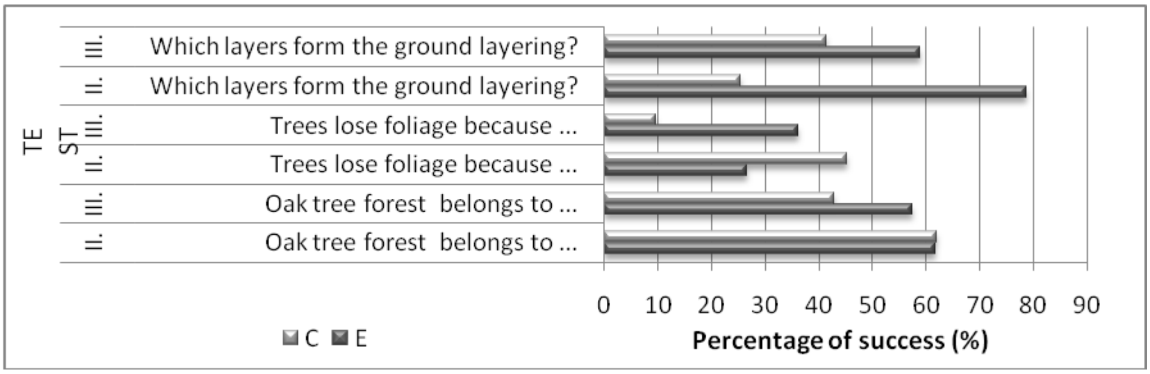

Figure 4. Results of solving the questions that repeat in Tests II and III of the experimental (E) and control (C) groups

By the analysis of mean value results for E and C groups, as well as the variability of the obtained results (Figure 5), in spite of lower variability of results for the C group, mean values for the E group are 6.8% (II. Test: E = 74,5±13,85; C = 67,7±13,44) and 8,5% (III. Test: E = 65,9±21,61; C = 57,4±21,13) higher compared to the C group = success in solving tests during the research decreases significantly in group C whereas group E shows better results. These conclusions are confirmed by significant differences between the E and C testing groups (II. Test: F(3,99) = 6,69; p<0,012; III. Test: F(3,99) = 4,63; p<0,035).

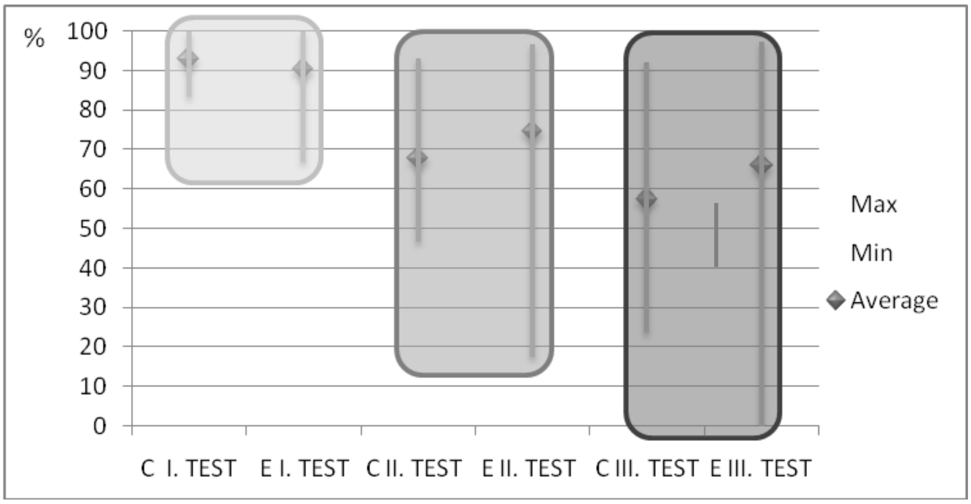

Figure 5. Range of results and mean values of pupils' results of three tests conducted in the research

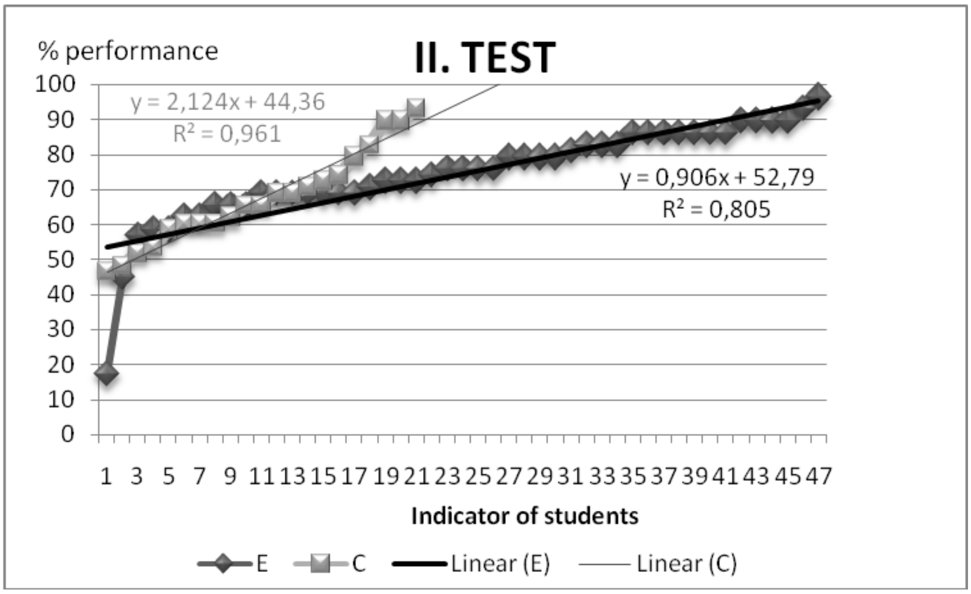

Figure 6. Linear regression of test result percentage for test II.

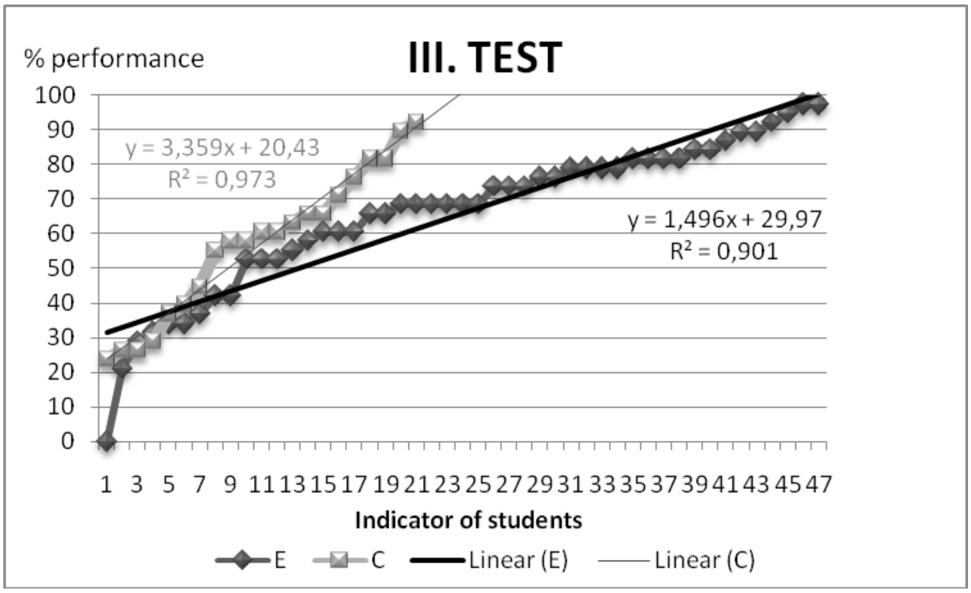

Figure 7. Linear regression of test result percentage for test III.

The data obtained by the research show that percentage of successful learning by using project methods increases and that the growth is more significant after the first project (II. Test) with more moderate slope of the regression line, whereas after the second project (III. Test) it is slower and more irregular with more significant regression line slope (Figure 6). The control group follows the results of the experimental group, which points to lower variability and better average success in solving test II (Figure 5). A smaller segment on the y axis indicates lower success in solving exercises, and the horizontal regression line shows higher balance in solving exercises, whereas the horizontality of regression line points to greater homogeneity of success among the examined pupils. The lowest value of the segment on y axis was noted among the pupils of the C group in Test III (Figure 7), which points to exceptionally bad results of group C in the last test (Figures 5 and 7).

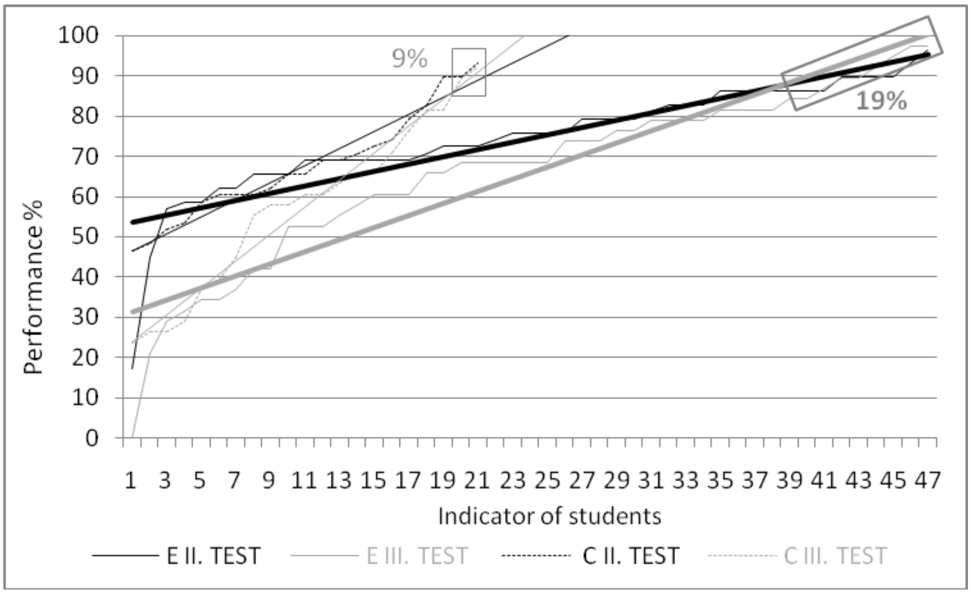

Figure 8. Differences in solving success of tests II. and III. in groups E and C

By final testing it was established that the most successful pupils (19%) achieve better results if the work includes the research of additional resources like during the implementation of the second project (Figure 8).

STUDENT'S QUESTIONNAIRE

Analysis of the questionnaire of the sixth-graders after the completion of the experiment showed that almost all pupils liked project work (from 87 to 91%) but field study is statistically better accepted ($F_{(2,66)}$= 3,68; p<0,01) compared to project work in a classroom. Satisfaction in project based learning highly correlates to the results achieved during testing of the pupils in group E (r = 0,99; r^2 = 0,98). As the main reason for accepting the project based form of learning 61% of pupils mention better interest, working in groups, going out to nature (54%) and better understanding among pupils (in questionnaires for fifth-graders who did not participate in the experiment related to the research (but they participated in in school in nature as part of prescribed fourth-year curriculum), pupils also say that they like when they participate in project work projektnoj nastavi i terenskoj nastavi., and a greater number of pupils says that they like field study). Statements of sixth- and fifth-grade pupils are in a significantly positive interrelationship (r = 0,99). Pupils quote similar reasons why they like school in nature: it is more interesting, they communicate more and better with other pupils, communication with teachers is better, they work more in groups or pairs, better atmosphere.

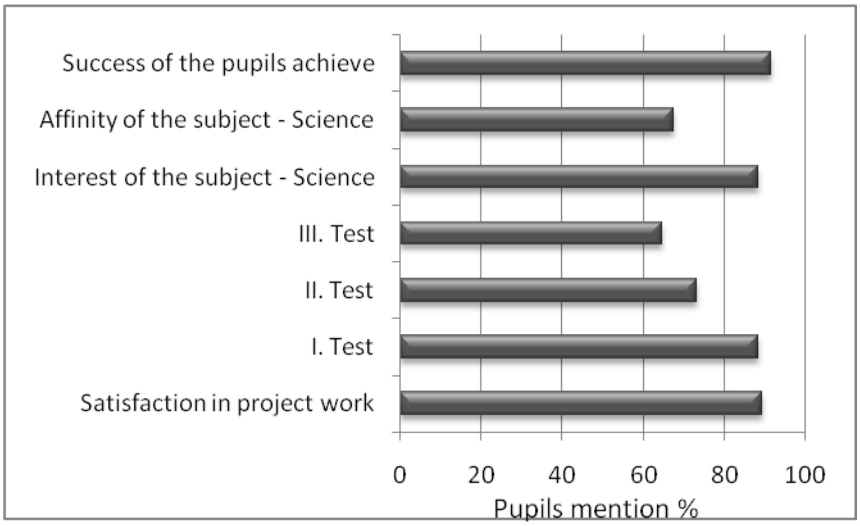

Figure 9. Connectivity of interest and learning success of the E group pupils

Satisfaction in project work, interest and affinity of the subject - Science, and success the pupils achieve during regular classes and during the research (Figure 9) show positive connectivity ($r = 0{,}68$; $r^2 = 0{,}46$).

Even 91% of the pupils think that they learned more by working on projects and during field study and therefore they want to practise it in the future, whereas 9% of pupils do not accept project tasks and thinks that that kind of teaching do not contribute to better learning results.

Out of all teaching methods used in class. pupils gave the highest mark to group work. To the question when they learn more, 71% of pupils answered that they learned the most when they combine teacher's lectures and individual work, 23 % of them said when they worked individually, and only 6 % during a teacher's lectures. This information shows the importance of systematisation of active forms of teaching. 65% of pupils assessed project approach to work with an excellent mark, 15 % as very good, 18 % good and 2 % insufficient.

DISCUSSION AND CONCLUSION

Pupils were more successful in the first project which included field study, and evaluated it as more amusing. The second project which included more theoretical work using the sources of data on deciduous forests, the majority of students evaluated as less interesting. The students were more successful in the first project, which was also assessed as amusing. The second project was experienced by most of the pupils as less interesting. Hodson (1996.) points out that learning biology is more successful with first-hand evidence and from field-study experience. The data that are not obtained directly often leave pupils not enough informed (Greaves et al, 1993). Learning success falls among the pupils in group C, as well as their motivation. The pupils from group E showed progress in learning success. On the other hand, the pupils from group C lose interest for a topic when the class ends. In spite of that, it is also shown that together with field study, the pupils who achieve best test results should be offered additional sources of knowledge as well. Cluster analysis of success in solving tests shows better success of solving tests after the first project (Luksa et al, 2009.), which points to better motivation that might have influenced better learning results, because larger number of pupils in the survey assess the first project as more interesting due to the field study. Rickinson et al. (2004) in their studies also emphasise positive changes that have arisen out of the application of field study in teaching which among others, contribute to better test results (Ballantyne and Packer, 2002; Lieberman and Hoody, 1998; Rickinson et al., 2004).

When evaluating teaching methods, all examined pupils assessed cooperative learning as the best, then group and pair work. We can suppose that the lack of this kind of work in group C might have caused fall of motivation and their lower results. The analysis of the survey of both graders shows that pupils accept project work but they prefer field study, which is in line with the results of other authors' research about field study as a way of active inclusion of pupils into a teaching process and in such a way a positive influence on the development of social competencies, acquisition of knowledge and development of pupils' attitudes (Martin et al, 1981; Bogner, 1998; Preston and Griffiths, 2004, Dillon et al, 2006). The results show that both the pupils who participated in the experiment and other surveyed pupils state similar reasons why they like field study – fun, entertainment, group work, going out to nature, better communication and understanding among pupils, better communication with teachers, better atmosphere. All the mentioned reasons support the statement that field study is essential for pupils' motivation (Ballantyne and Packer, 2002; Lieberman and Hoody, 1998; Rickinson et al.,2004). Pupils also think that through field study they learn more successfully, and only 9% of the pupils do not agree with that statement. It is especially interesting that they mentioned, as the best way of learning, the combination of teacher's lectures and individual work which indicates the importance of systematisation of active teaching methods.

Although field study is not represented enough in teaching, the fact that the awareness of the importance and need of organising field study more often is encouraging, and the results of this research show that use of project based teaching, primarily accompanied by field study, may be an ideal solution for pupils' motivation, and as a result of that, better success in learning.

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NEED FOR NOVICE SCIENCE TEACHERS' CONTINUAL PROFESSIONAL DEVELOPMENT

Birgitte Lund Nielsen

Center for Science Education, Aarhus University

bln@cse.au.dk

ABSTRACT

Results from a survey of a local cohort of newly qualified Danish science teachers before they began their first jobs in primary and lower secondary schools (n=110) show a need for continual *Professional Development* (PD). The results highlight two main areas of concern based on the newly qualified teachers´ reflections on scenarios of science teaching, their considerations about themselves as future science teachers etc.

These include a tendency for the teachers to limit *Inquiry Based Science Teaching* to *activity driven science*, which suggests there is a need both in in-service PD and pre-service training to nudge the teachers away from science activities for motivation alone and towards students' learning and how they may become scientifically 'literate'. Furthermore the results suggest that beliefs held by the teachers about their own subject matter knowledge may, for a large subgroup in the cohort, affect how the teachers' approach the physics content when teaching primary Science & Technology (grade 1-6 in the Danish schools). Beside this the cohort can be divided into subgroups with great variation in strengths and weaknesses when it comes to being agents in contemporary science teaching. This description of subgroups may be an analytical tool when planning school based PD.

INTRODUCTION

Crossing the border between pre-service teacher training and the first position as a qualified science teacher is a critical phase, which has been the subject of wide ranging research and developmental work. This has often focused on particular issues raised by the novice teachers and has examined what induction features could address these demands (Britton, Paine, Pimm & Raizen, 2003*;* Davis, Petish & Smithey, 2006).

But induction is not the only issue when discussing the need for continual Professional Development (PD) after pre-service training. There seems to be a need for sustained learning opportunities that span the whole teaching career (Feinam-Nemser, 2001), not least in the complex field of science teaching.

For many years it has been known that children's early experiences with science in primary and lower secondary schools are crucial in relation to creating scientifically literate citizens, and that teachers play a significant role in determining students' attitudes to school science and their subject choices (Osborne, Simon & Collins, 2003). It is widely agreed that teachers are among the most significant factors in educational reforms of all kinds (Borko, 2004), and maybe the single most important factor in relation to the quality of science education (Osborne et al., 2003). What students learn is directly related to how teachers teach and if schools are expected to produce more powerful learning on the part of students, teachers must be offered more powerful learning opportunities (Feinam-Nemser, 2001). Research in this area suggests that science teachers, novices as well as experienced teachers, seem to need tools to critically examine, reflect on and discuss their own and others´ practice in order to continuously enhance their competence in teaching the highly complex content of science. But Professional Development (PD) opportunities are often sporadic and isolated, even though there is a growing consensus that PD activities yield the best results when they are long-term, school based, collaborative and focused on student learning (Hiebert et al 2002; Shulman & Shulman, 2004; Roth 2007; Anderson, 2007).

In Denmark there is a relatively new research project, which is trying to redress the way of framing PD and which aims to take into account the principals set out above. The Danish science teachers are involved in collaborative learning groups and given the opportunity to consider, evaluate and reflect upon their own practice through the use of video and other artifacts of practice. To qualify and evaluate the work in these learning groups and to be able to back a claim that specified PD activities in these groups are meeting some vital challenges, there is a need to know in more detail *what* are the vital challenges in Denmark? What are the demands of a local Danish cohort of science teachers in terms of continual professional development after pre-service training? The research presented in this paper is a background study created with the aim of producing such a diagnosis.

RESEARCH QUESTIONS

- *What are the professional starting points for teaching science for a cohort of new Danish science teachers?*
- *What might help or hinder the new teachers in being agents in contemporary science teaching and what seems to be the demand for continual professional development?*

THEORETICAL BACKGROUND

The term: *Professional starting point* in this study includes the teachers' backgrounds in science in and before teacher training, the way the new teachers feel prepared to teach various sub content in science and basic elements of knowledge and beliefs about science teaching as expressed in their reflections on their own school practice experiences and a range of science teaching scenarios. The aim is to characterize the cohort, examine possible variation within the cohort and to compare these findings with the contemporary visions and recommendations about science teaching based on research and recent policy papers.

TEACHERS' KNOWLEDGE, BELIEFS & ORIENTATIONS

The work of science teachers is complex, highly dynamic and requires lots of decision making, as well as knowledge. At the same time personal beliefs, practices and values impact in a broad range of ways (Wallace & Loughran, 2003) on how any one individual teaches. Pedagogical Content Knowledge (PCK) has for the last 25 years been used as a construct to indentify teachers' professional knowledge (and beliefs), i.e. for science teachers that would be the best way of teaching specific science content and concepts to particular groups of students (Shulman, 1986; 1987; Abell 2007; 2008). PCK is highly content and context dependant and to "measure" a teacher's PCK is not easy, if at all possible (Baxter & Lederman, 1999). The term professional starting point includes basic elements of science teacher beliefs with the aim of characterizing a cohort, *not* to understand in depth the PCK of a single or a few teachers in reference to a specific science area, like in the ongoing PCK research program (e.g. Abell, 2008, et al. in theme number of International Journal of Science Education, Vol.30). But along with the fundamental understanding, that learning to teach involves integrating/transforming different kind of knowledge: subject matter knowledge, pedagogical knowledge and knowledge of school context (Feinam-Nemser, 2001), certain PCK sub-elements, prove useful in the analysis and discussion.

Research has shown that teachers' beliefs are an important element when they make decisions in their practice; teachers may have similar knowledge but teach in very different ways. Existing knowledge and beliefs are often tacit, but still critical in shaping what teachers learn when involved in PD (Pajares, 1992; Friedrichsen & Dana, 2003).

When looking into science teachers' practices various *orientations* (knowledge and beliefs about the purposes and goals of teaching science) have been used in research, e.g. nine different science teaching orientations: process, activity-driven, discovery, project based etc. (Magnusson et. al, 1999). But later research has shown that prospective and practicing teachers often show a mix of orientations when exposed to a range of science teaching scenarios in a card-sorting task, which suggests that teachers can hold multiple teaching orientations (Friedrichsen & Dana, 2003). In a research review it is concluded that teachers' orientations towards teaching science are a messy construct, context specific and not coherent (Abell, 2007) and as Friedrichsen and Dana warn, this makes it difficult to build up a precise profile of an individual teacher from reflections on scenarios from science teaching. But the tool of using scenarios can still be useful to help teachers articulate knowledge and beliefs (Friedrichsen & Dana, 2003) and may therefore be a useful tool for looking into what characterises *a cohort of teachers*, for example the distinction between a *student centred conception* of science teaching versus *a teacher centred conception* and an *activity driven orientation* versus *a transmission orientation* (Abell & McDonald, 2006; Abell, 2007). When looking into teachers' views on students' inquiry a continuum of approaches have been seen in research, where the extremes can be labelled an "old orientation" versus a "new orientation" (Anderson, 2007). The one extreme is a transmission orientation, a t*eacher centred conception with teacher as dispenser of knowledge and students as passive receivers working with teacher specified activities*. The "new orientation" is a *student centred conception,* seeing *teacher as coach and facilitator and student as a self-directed learner* (Anderson, 2007). A tri-partition is also used in the field of science education research; what Anderson calls the old orientation can also be labelled *a traditionalist teacher,* the other two orientations being: *the process oriented teacher* (who focuses on scientific methods and experimental knowledge) and the *constructivist teacher* (who helps students construct knowledge)(Tsai, 2002).

CONTEMPORARY SCIENCE TEACHING

When using the term contemporary science teaching in this study it is with reference to research in the field of science education as well as recent important policy papers. This is in line with recommendations for research to synthesize what is known (about teacher education and professional development) from research and the organizational context at the policy level (Grossman & McDonald, 2008). The recommendation of an EU initiated expert group in broad terms signals a move away from school science-teaching pedagogy that advocates mainly a deductive approach and suggests Inquiry Based Science Education (IBSE) (Rocard, 2008) instead. The group found evidence connecting the way science is being taught and young peoples' attitudes towards science: traditional science education can stifle young children's natural interest in science and have a negative impact on their attitude towards learning science (Rocard, 2008). This is supported by research showing that students desire more opportunities for practical work in science classes, extended investigations that encourage student autonomy and discussions (Osborne et al., 2003).

Inquiry has been a prominent theme in science curriculum improvements since the post-Sputnik era (Anderson, 2007), so what is new about the IBSE? Many current notions still reveal a preconceived idea, which limits inquiry in the science classroom to "hands on" and/or student "originated activity", but building on Bybee, 2006 IBSE is not a single teaching strategy. Essential features of inquiry in the science classroom according to Bybee are that:

- the learner engages in scientifically oriented questions
- the learner prioritizes evidence in responding to questions

- the learner formulates explanations from evidence
- the learner connects explanations to scientific knowledge
- the learner communicates and justifies explanations.

These points highlight that inquiry should not be limited to learners' hands-on experiences based on self-formulated questions and problems, but that the learners' explanations and communication should also be taken into consideration. Grounded in a socio-cognitive perspective on science learning such an *integrated approach to inquiry* (Abell & McDonald, 2006) is important, this means as well as "hands-on" there should be "heads-on" - that is learners should be given the chance to talk science as well as do science. In such a view on IBSE the *process oriented* approach suggested by Tsai seems to have merged with the *constructivist* approach.

IBSE as an important aspect of contemporary science teaching is also emphasized by another recent European policy paper: *Science education in Europe - critical reflections* (Osborne & Dillon, 2008). This paper claims that school science is still dominated by transmission, with opportunities for students' argumentation being rare and few chances for students to use the language of science, to discuss and to think critically. Additionally the argument is that the focus on foundational knowledge of sciences like biology, chemistry and physics is not enough when the vision is *science for all,* not just for future scientists. The nature of science is an important element and there is furthermore a need to consider how teachers are prepared for teaching integrated science (Osborne & Dillon, 2008), e.g. Socio Scientific Issues (SSI).

Research shows, that it is not enough to discuss how to challenge the traditionalist transmission orientation to teaching science, as other studies have highlighted the opposite problem: a purely activity-driven orientation; students spending a lot of time doing science, but little time thinking, talking, posing questions, or constructing explanations – all with the goal of making science fun, while forgetting the goal of students achieving understanding (Abell & McDonald, 2006). A study that aimed to profile a local cohort of US pre-service primary science teachers enrolled in a method course shows a tendency towards focusing on making science interesting, enjoyable and fun through activities, without mentioning what was learned (Abell et al., 1998). This study additionally describes a widely held lack of confidence with science teaching based on these novice primary science teachers' negative experiences as learners and a tendency towards judgmental frames, which can make it difficult to see the complexity in the classroom. There was also a tendency to rely on buzz-words (exact text-book phrasing)(Abell et al., 1998). From such studies it seems that it is important to be aware of the activity-driven extreme when looking at primary science teachers, while the traditionalist view maybe more common among secondary science teachers as mentioned by Osborne et al. (above) and as noted in the study by Tsai, 2001.

SCIENCE TEACHERS IN DENMARK

There has not been much research on the characteristics of Danish pre-service science teachers. In Denmark there is a division between training to become a primary or lower secondary teacher, which takes place at a University Colleges (UC) (this cohort), and training to be an upper secondary teacher at a university. The UC has in the public debate been criticized for valuing the pedagogical content over subject matter, while concern is of an opposite character when it comes to education of teachers for upper secondary (Danish gymnasium): solid subject matter background, but maybe not so much pedagogy. Students entering teacher education at a UC have been referred to as having a humanistic profile and concern has been raised about graduation of too few new teachers with a science specialisation and that some of those who have graduated having too little background in science subject matter. A recent reform aimed to strengthen science lead to raised admission requirements and ETCS for science, with the immediate result that fewer students took science specialisations. So there is definitely a need for new reforms. The cohort in this study entered *before* the reform outlined above and can be seen to represent a typical cohort of the science teachers out in the school system at the moment. When searching for a diagnosis of – a reason for - the demand for continual PD in a Danish setting in this study it is with this local Danish context in mind, as well as with reference to the more general discussions in contemporary science teaching outlined earlier.

METHOD

Sample

Informants are novice science teachers who graduated in June 2009 from VIAUC Teacher Education in Aarhus (n=110). This is the full local cohort who specialized in the four science subjects offered in training for Danish primary and lower secondary teachers: Biology, Physics & Chemistry, Geography and Science & Technology (the three first subjects are taught in lower secondary, grade 7-9, while the last, Science & Technology, is primary science, grade 1-6). The response rate was 79%, calculated on the background of the 87 informants who completed the full questionnaire. No replies are distributed over all four specialisations.

Data collection

Data was sampled through a semi-structured web-based questionnaire, containing Likert scaled questions revealing background information, but with central questions seeking additional open ended, word based answers due to the exploratory character of the part of the study focused on the novice teacher reflections (Cohen, Manion & Morrison, 2008). All Likert scales were 5 point scales.

The questionnaire was administered at the end of training, but before the informants started work as teachers. Data include the teachers' answers about their background in science subjects, how well they felt prepared in relation to various issues of science teaching (partly based on Darling-Hammond, 2000, p.93-94), their considerations about themselves as future science teachers in various subject matter areas, reflections on what they have learned from school practice and furthermore their reflections on a range of science teaching scenarios (Friederichsen & Dana, 2003).

These scenarios were used in interviews by Friedrichsen & Dana, and are also used in interviews in the learning group part of the full research project referred to here; the open ended approach in the questionnaire is a pragmatic choice: "as close as possible" to a qualitative methodology, but still covering a broader group of informants (the aim of profiling a cohort). The questionnaire was piloted and refined before final data collection

ANALYSIS

Analysis of Likert scaled answers included frequency analysis and cross tabulations.

Open answers were approached as qualitative data with methods from content analysis (Cohen et al., 2007). The answers were categorised and coded using partly open coding: an inductive start of analysis grounded in the data, with the aim of avoiding codes and categories to predefine the data analysis (Cohen et al., 2007). After this first repeated reading of the open answers to seek patterns and categories, final categories and coding were framed which also referred to the theoretical background. For example the main categories when coding reflection on school practice experiences were "*student-centred*" versus "*teacher-centred*" (Abell & McDonald, 2006; Abell, 2007), but subcategories (*students' learning*, *students' interest/motivation*, *teacher planning*, *teachers' knowledge* etc.) were also included based on data. Likewise the coding of the arguments (negative or positive) about teaching a certain subject distinguished between arguments suggesting (lack of) *personal interest*, *subject specialization* or *subject matter knowledge* based on patterns seen in the first readings of data. The coding of reflections on scenarios was theory-based referring to teacher-orientations and main categories of teacher knowledge (Friederichsen & Dana, 2003; Abell & McDonald, 2006; Anderson, 2007; Abell, 2007). For example are general pedagogical phrases, science education phrases, reference to you own SMK, reference to students being active/passive, reference to students motivation and self-determination, reference to curriculum, reference to socio-scientific issue used in coding reflections.

All coding of open answers was done separately by two researchers. Inter coder reliability was more than 80% from the beginning and afterwards coding with incongruence was refined. After coding frequency analysis etc. was completed, correspondence analysis was conducted to examine possible sub groups in the cohort.

RESULTS

Only a third of the cohort started their pre-service training with a high level background in science. Based on the answers about subjects and levels gained in the science subjects at upper secondary level (the Danish gymnasium) the informants can be divided into two groups: high level background before teacher training or low level background. This is built upon *how much* science they took: A, B or C level, not on their marks. Three combinations are coded as high level: two A; one A + one B or two C; two B + one C. The result from making this rough division is 30% of the cohort had a high level background and 70% had a low level background. This is not evenly divided between teachers who have taken the various science specializations. For those who have chosen the Physics/ Chemistry specialization it is 62.5% High/37.5 % Low, Biology 24% High/76% low, Science & Technology 31% high/69% low, Geography 21% high/79% low.

There is clearly a large group of these new teachers who have only a basic background in science from secondary school, and many informants also emphasize their humanistic background in an open category, where they are asked if they are thinking about themselves as *science*-teachers (57% of replies suggested their teacher identity was attached to areas other than science). But does this mean a lack of interest in the science related area? When asked their reason for choosing a science specialisation (in a Danish context where science includes life science and earth science) 42% had always had an interest and 58% found science subjects interesting in school. Other answers in this category included job opportunities (38%) and 37% who said their interest was stimulated by what older students said at the introduction meeting at the UC.

When asked if they wanted to teach various science sub-content all the teachers of course said that they would prefer to teach their own specialization, but more teachers expressed a readiness to teach Science & Technology, Geography and Biology without having a specialization than Physics/Chemistry. When analyzing which arguments are used for not wanting to teach some given science sub-content analysis shows a partition in the cohort where arguments grounded in lack of subject matter knowledge (SMK) is expressed more often by teachers with Geography, Biology and Science & Technology specializations, than by teachers with a Physics/Chemistry specialization (comments on *all* sub-content combined). The teachers with a Physics/Chemistry specialization seem to feel more prepared to teach all sub-content, content related to life and earth science as well, and if they argue for not wanting to do it, their arguments are typically about not having subject specialization. Arguments about lack of SMK like: "*….how could I possibly teach something I do not understand at all myself",* are really only used by the teachers with the other 3 specialisations, especially when asked about teaching Physics, but also expressed in reflections about Science & Technology (primary science), in comments like: "..*I am not good in the physics part*…"

When asked about how well they felt prepared in reference to a range of pedagogical issues in science teaching (Darling-Hammond, 2000), the results show that the new teachers in general feel quite well prepared, but some interesting patterns do show in relation to activity/IBSE. When asked in general about activities the new teachers felt better prepared than when asked about science inquiries more specifically: 72% felt very well or well prepared for using approaches where students are active, but in the answers about planning and organizing students' inquiries this is 49%. This pattern is repeated when looking into science discourse: 72% feel very well or well prepared for supporting students' conceptual understanding, but when asked in more detail about discourse the feeling of being prepared falls: 55% feel well prepared for using (teacher) questions to support students learning.

From the reflections on the various scenarios *science teaching based on practical work and students' activities* seems to be an ideal for nearly all of the teachers. None of the teachers expressed a traditionalist view. The positive arguments about activity or negative arguments about passive students are seldom warranted in students' learning (or lack of learning) through the activity. A large group of the teachers typically use students' motivation; *what might be interesting/boring for students,* in their argumentation, another group typically use phrases from the field of science education such as hypothesis, *the* scientific method etc. in many of their arguments. The focus for all teachers is much more on science as a process than science as a body of knowledge and the school curriculum is nearly absent in arguing about the scenarios; the arguments are not about this particular subject matter being relevant or in the curriculum, it is for example about the approach being motivating. Reflections about "bildung" and that some themes are SSI are included by many of the new teachers.

One example of teacher reflections on a scenario where *students observe earthworms, generate questions and design an experiment*, showed that 40% of the teachers refer to students' inquiries in their argumentation about this scenario, but only a few of these (1/10) include the discursive element. A few of the teachers who refer to inquiry, explicitly mention what they call <u>the</u> scientific method when arguing. These teachers all have a Physics/Chemistry specialization and a high level background. Around 25% of the arguments about the earthworm scenario refer to active/motivated students without mentioning anything about inquiry, hypothesis, scientific method etc. These comments were made by teachers without specialisation in Physics/Chemistry.

Another example involves the reflections on a scenario where *students experiment with batteries, bulbs and wires to find possible ways to light the bulb*. In this instance 50% of the arguments explicitly refer to students being active; among these 1/5 also refer to the activity (hands on) as well as the discursive element being important. Again a few with a specialisation in Physics/Chemistry refer to *the* scientific method. 20% of the arguments about this scenario refer to a lack of SMK as a limitation, when discussing the scenario.

In the reflections on their school practice experiences during teacher training there are more teacher centred reflections than student-centred. As much as 65 % of the argumentation focuses on what they did or didn't do themselves as teachers while reflections about how to challenge student learning are far less common.

DISCUSSION AND CONCLUSIONS

The results point to at least two important issues: the newly qualified teachers' approach to physics subject matter and their approach to and beliefs about "ideal" school science.

The UC education in Denmark has been accused of valuing the pedagogical content over subject matter. The aim here is not to draw conclusions about whether the members of this cohort have sufficient background in science subject matter, because that raises the question of what is meant by 'sufficient background'? What is the ideal balance between SMK and knowledge about teaching? Research suggests that SMK is an issue for being an effective science teacher, but *not* that SMK is more important for teacher effectiveness than knowledge of how to teach (Darling-Hammond & Youngs, 2002). What you *can* say is that for a subgroup of these teachers' *beliefs about own SMK in the physics area* might very well affect the way they for example will teach primary science (while in principle the full cohort is qualified). You might try to navigate around letting your students experiment with simple electrical circuits as a primary science teacher, as illustrated by some of the teachers' comments about a scenario in which a 4th Grade science teacher encourages the students to find ways to light the bulb using batteries, bulbs and wires is: *This sounds dangerous*; *I have no subject matter background to answer the question*, *no I do not feel competent enough.* From the cohort under discussion 17% placed this scenario in the *I don't know* Likert category, when asked if it is an approach they would consider taking. But still 57% of the teachers placed the scenario in the two upper Likert scaled categories and there are several examples of balanced (IBSE) reflections like: "…*students are using their hands and you can add theory while they are working and afterwards.."* or "..*a good approach where the foundation is the student's experiments. The teacher of course has to follow up on students' experiences…"*

What might help or hinder the new teachers in being agents in contemporary science teaching? A lack of belief in their own SMK in the physics subject area may very well hinder the teachers who gave the first type of reflections; their PCK for teaching simple electrical circuits is affected by their SMK. This scenario and another referring to typically physics SMK (*a water toy rocket a classmate brought to school…identify questions and ways to explore how the rocket works…*) is where most teachers use the *I don't know* Likert category (19,3% in the latter) and where more reflections are coded with negative reference to the teachers' own SMKs, than reflections about scenarios referring to life science or earth science. The analysis points to a tendency for some teachers without a physics specialization to use value-loaded arguments: "*I know nothing about physics*", "*this is my weak side*" which points to negative experiences with working with this field. Some of this may be grounded in a variance in background in science before starting teacher training, whereas around 60% of the teachers with a Physics/Chemistry specialization have a high level background, around 25% of the teachers with the other 3 specializations have a similar background. But maybe these examples of low efficacy beliefs attached to physics go back to how these teachers themselves experienced different content fields when at school. The variation might be due to a lack of confidence based on negative experiences as learners, similar to the results from US primary science teachers (Abell et al, 1998). The conclusion on this point is likely to go beyond the theoretical and empirical background in this study.

One point for optimism in the study, when considering IBSE, is that none of the teachers seemed to identify themselves as having a traditionalist transmission orientation (Tsai, 2001; Abell & McDonald, 2006; Anderson 2007; Abell, 2007), although you have to be aware that what is seen here are the newly qualified teachers' ideals (*what they say, they want to do*), what they actually are going to do in complex and sometimes confusing classroom situations is beyond the scope of this study. Examples where teachers use a transmission approach though expressing a constructivist orientation are well-known.

The tendency to focus on activity driven science (hands on without mentioning minds on) of a large subgroup as well as the emphasis placed on *the* scientific method by a small sub-group (teachers with high level SMK and Physics/Chemistry specialization) are both important issues when discussing "*what might hinder".* In reference to the tendency to emphasize one specific scientific method a focus on the nature of science might be an important element in continual PD although these teachers have a high level of SMK, they may not be well prepared for teaching *integrated* science (Osborne & Dillon, 2008).

The conclusion is that there is a need for a balanced view on IBSE and a change of focus towards students' learning of science is clearly needed as part of PD for nearly all the members of the cohort. At the same time it is possible to divide the cohort into subgroups with *very different* backgrounds and *great variation* in strengths and weaknesses when it comes to being agents in contemporary science teaching. This does *not* mean that a division into clearly defined subgroups with clear description and limitations is easy. The qualitative data (the reflections) point to a cohort consisting of individual teachers each with their own biography and many variables that affect their approach to being a science teacher, but the vague contours of sub-groups do show, for example:

- Teachers with a specialization in Science &Technology, who have taken this subject as a part of the primary teacher training and do not necessarily intend to become a science teacher typically have a low level background in science, and an activity driven orientation appreciating activities which are motivating for primary students, and emphasizing pedagogical approaches in primary teaching in their reflections. Some express a lack of belief in their own SMK in the physics area.
- Teachers with a specialization in Biology (and fewer in Geography) who value outdoor activity highly and many combine this with sports as another specialisation in teacher training. They also note that they have always been interested in "science", but not necessarily science in the school system (*a scout approach?*).
- Teachers with a specialisation in Geography (and fewer in Biology), with an explicitly formulated humanistic profile and who do not see their teacher identity attached to being a science teacher, emphasize (global) "bildung" in their argumentation and many SSI as well. Many express a lack of belief in their own SMK in the physics area and a lack of interest in physics.
- Teachers who specialize in Physics/Chemistry and who identify themselves as science teachers, usually have a high level background and mathematics as another specialization and say that their interest developed from their own school experiences (some explicitly express that they love physics). These teachers typically gave short (word based) reflections and offered process orientation (Tsai, 2001). Some of these teachers use the expression "*the* scientific method"

It must not be concluded from these points that all teachers belong to these categories. Most members of the cohort are somewhere in between: some Geography and Science & Technology teachers have a high level science background and an interest in physics, some teachers have several specialisations and combinations of science subjects, some teachers, with Physics and Chemistry as well as other specializations, show orientation where the process and the constructivist orientation "melt together" etc. These subgroups are more like Max Webers ideal types: *idea-constructs that help put the chaos of social reality in order*. Description and a clear understanding of such subgroups (and their associated needs) may be an important "analytical tools" when planning school based PD, while it is likely that there will be great variation in background in science and orientation towards science among the teachers at one particular institution.

PERSPECTIVES

The results point to a need for continual professional development attached to the physics content and a balanced conception of IBSE as well as an awareness that there is considerable variation found when characterizing a cohort. Great variation can also be expected to be found in a science team at a given school and must be taken into consideration when planning school based PD activities.

The results furthermore suggest that there may be a need for reforms in the institutional framing of science teaching and science teacher education in Denmark.The political answer so far in Denmark has been the reforms regarding the need for a high level science background mentioned above. The consequence has been an enormous problem with recruiting students for science specializations in teacher training. This might have been predicted: nearly 70% from the cohort discussed wouldn't be allowed to take their science specializations with the current UC admission requirements. There is no easy way to solve the problems. Raising admission requirements and trying to recruit more students with a high level science background is a reasonable political step, but there might be other ways of approaching the challenges, seeing beyond what is for example the immediate understanding of what makes a good primary science teacher. Lack of belief in one's own SMK in important areas of science are shown to be a problem in this study, but continual PD might address some of these concerns and you might be able to build upon the teachers' existing competences in the general field of primary teaching.

Maybe the division into Physics/ Chemistry, Biology and Geography in lower secondary leads to divided cultures attached to science specializations, which can be followed all the way through the educational system, especially with physics which seems to have its own culture and produces few teachers who want to be resource teachers in primary and lower secondary school (and attracts few school students)? And maybe in Denmark the division between training for primary and lower secondary school in one system and training for upper secondary school in another also has to be discussed?

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ENGAGING SECONDARY SCHOOL LEARNERS EFFECTIVELY IN SCIENCE: VOICES OF STUDENTS AND TEACHERS

Bill MacIntyre

Massey University

w.r.macintyre@massey.ac.nz

Dianne Gardner

Massey University

D.H.gardner@massey.ac.nz

Marg Gilling

Massey University

m.gilling@massey.ac.nz

Helen Hughes

Massey University

h.hughes@massey.ac.nz

Tim Parkinson

Massey University

t.j.parkinson@massey.ac.nz

Bob Rosemergy

Educational Consultant

Gordon Suddaby

Massey University

g.t.suddaby@massey.ac.nz

ABSTRACT

A multidisciplinary team carried out research to help a New Zealand university understand how to better engage their learners in the sciences, particularly in transition from secondary schools to tertiary institutes in Aotearoa New Zealand. The aim of the research is to develop a framework that will facilitate the transition of science education learners between secondary schools and tertiary institutes while maintaining key elements of engagement. A survey instrument was developed to collect quantitative evidence of engagement from four different groups: Year 12 (age 17) students and their teachers, first year university students and their lecturers. Analysis of the survey data for Year 12 students and teachers indicates that there is a significant difference between the students and teachers perceptions on some key elements of engagement in science.

Keywords: *secondary, students, teachers, engagement, science.*

INTRODUCTION

This paper will present *one part* of an Ako Aotearoa research funded project titled - *Engaging learners effectively in science, technology and engineering: the pathway from secondary to university education*. A multidisciplinary team with members from the College of Sciences, College of Education and College of Humanities and Social Sciences, conducted research to help this New Zealand university understand how to better engage their learners in first year sciences courses, particularly in transition from secondary schools to tertiary institutes in Aotearoa New Zealand. The intent is (a) develop a framework that will facilitate the transition of science education learners between secondary schools and tertiary institutes while maintaining key elements of engagement; (b) increase student retention in first year university science courses and (c) increase the number of students taking Science Technology Engineering and Mathematics (STEM)-related subjects.

BACKGROUND

Concerns about student decline in secondary science and tertiary science courses have been expressed since 2003. In 2003, Fullerton, Walker, Ainley and Hillman's reported a marked decline in the number of students enrolled in science classes of their last year of secondary schooling in Australia. A European Commission (2004) report noted the decline in recruiting, retention of students studying science, engineering and technology. Lyons (2006) in his comparison of three studies in Australia, Sweden and England of secondary school science students identified core themes linked to decline in interest and enrolments in secondary and universities. Panizzon and Westwell (2007) and Tytler (2007) also noted in their reports the decline and engagement of students in the science, technology, engineering and mathematics in Australia was not unique and is similar to many OECD countries.

A common factor in the literature on engagement appears to centre on students' attitude and the pedagogical approach taken by teachers. Hattie (2003), in his meta-analysis of student achievement, indicated that 30% of student achievement was dependent on the teachers' impact with students. He identified different aspects of quality teaching that had positive affects on students. The focus on the teachers of science was acknowledged by Tytler (2007) when he stated that changes in science education has been resisted because of science teachers' '*silent choice*' for the status quo while Osborne and Dillon (2008) draw our attention to the pedagogy of school science using the '*conduit*' metaphor – transmission of science knowledge and understanding by teachers. The New Zealand Council for Educational Research (NZCER) report (2006) to Ministry of Research, Science and Technology supports this focus on teachers. Hipkins, Roberts, Bolstead and Ferral found in their research that approximately one-third of the Year 13 (age 18) students taking sciences found their subjects were sometimes taught in a boring way.

In identifying science engagement for secondary or first year university students, the goals of science education (Years 1 – 13) in Aotearoa New Zealand need to be acknowledged as that is what the teachers are focusing on in their teaching. The goals of science education can be identified in *The New Zealand Curriculum* (Ministry of Education, 2007:28) document with the question – Why study science?

> *By studying science, students:*
> - *develop an understanding of the world, built on current scientific theories;*
> - *learn that science involves particular processes and ways of developing and organizing knowledge and that these continue to evolve;*
> - *use their current scientific knowledge and skills for problem solving and developing further knowledge;*
> - *use scientific knowledge and skills to make informed decisions about the*

communication, application, and implications of science as these relate to their own lives and cultures and to the sustainability of the environment.

The rationale for engaging with these science goals is to be commended, as they will hopefully provide Aotearoa New Zealand with scientifically literate citizens.

Therefore as fewer and fewer students enroll in science (secondary and university) and the engagement rate lowers, Massey University College of Sciences recognized the need to identify specific aspects of the teaching and learning in science that influence the engagement and retention. Identifying those impact factors associated with the teacher / lecturer would assist with reversing the trend but also guide Massey University College of Science in repositioning their science papers for the 21st century. With that in mind, the research team set about investigating the secondary and tertiary experiences of students (Figure 1) and teachers / lecturers (Figure 2) in science education.

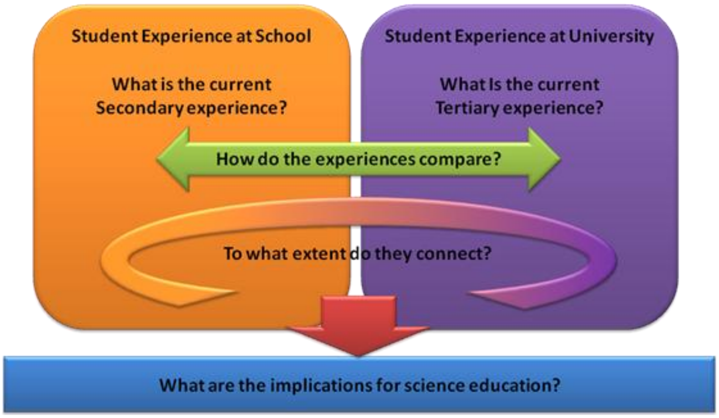

Figure 1. Comparison of student experience in secondary and tertiary science education

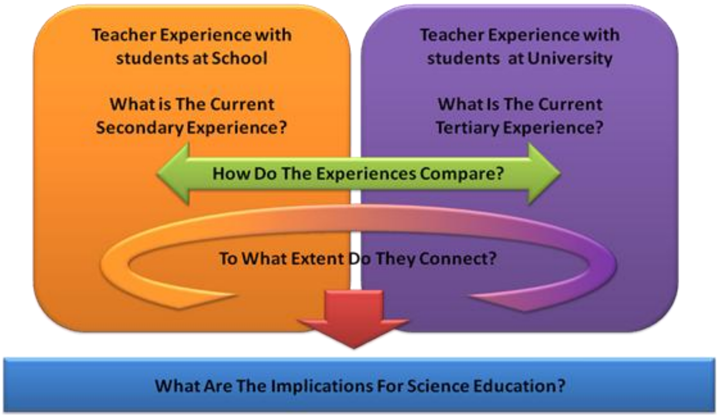

Figure 2. Comparison of teachers / lecturers experience in secondary and tertiary science education

METHODOLOGY

The research team employed a qualitative and a quantitative approach to collect the data from the four participant groups: (i) Year 12 (age 17) high school students, (ii) high school science teachers of the Year 12 students, (iii) Year 1 university students enrolled in a science course and (iv) university staff who teach or have responsibility for Year 1 science programmes. The qualitative approach used focus groups or one-to-one interviews. Similar focus questions (Table 1) were used for secondary or tertiary students and secondary teachers or lecturers. The quantitative approach used a questionnaire, which the authors will focus of this paper, for all participant groups.

Table 1. Focus questions for students and teachers

Students	Teachers
Q1. What do you like most about science?	Q1. Write three things that 'turn on' your students in your science class
Q2. When I am in science class:	Q2. When your students leave school, *what knowledge, skills and attitudes in science do you hope that they will have learnt in your classes?*
(a) I really like it when …	Q3. To achieve this goal, what do you think your current students should (i) continue, (ii) stop / do less of, (iii) start / do more of?
(b) I really don't like it when …	Q4. To achieve this goal, what do you think you or the school should (i) continue, (ii) stop / do less of, (iii) start / do more of?
(c) It would be better if …	Q5. If you could give one piece of advice to university teachers, what would it be?
Q3. What are your plans for science next year?	

Questionnaire

The questionnaire consisted of 100 questions using a five point Likert scale (1 = never, 2 = rarely, 3 = sometimes, 4 = often and 5 = always). In order to identify patterns and trends in the data, similar questions were used for the students (high school and university) and for teachers (high school and university). The design of the questionnaire was to link to literature on engagement in science (Lyons 2003, Hipkins et al 2006, Tytler 2007, Osborne and Dillon 2008 and Panizzon and Westwell, 2009), the nature of science (Ministry of Education, 2007) and the pedagogy for teaching science effectively in the classroom (Tytler 2003). Questions were identified that linked to

(a) to the broad range of affective experiences the students / teachers might encounter in a secondary or tertiary setting;
(b) to the declarative / procedural experiences the students / teachers might encounter in a secondary or tertiary setting and
(c) to effective science teaching in classrooms (Tytler, 2003 – School Innovation in Science Project).

The questions were grouped into two broad sets. One set of questions (n = 50) placed an emphasis on extrinsic factors - the teacher is directing the science engagement. An example question (Q.32) is provided from the teacher and student questionnaire. Note that the experience is being directed pedagogically from the teacher.

> Question 32:
> Teacher questionnaire - I give students the opportunity to influence the way that they are taught
> Student questionnaire - I am given the opportunity to influence the way that I am taught

The focus of the other set (n = 50) of similar questions places an emphasis on personal intrinsic factors. A teacher and student example (Q.91) is provided to demonstrate the subtle difference from the previous questions above. Student initiative is being emphasised although the stem of the question is basically the same as question 32.

Question 91:
Teacher questionnaire - Students take opportunities to influence the way that they are taught
Student questionnaire - I take opportunities to influence what topics I am taught

Due to time restrictions placed on this project the questionnaire has not been validated through normal statistical procedure.

RESULTS AND DISCUSSION

The total number of participants who completed the questionnaire in each group is identified in Table 2.

Table 2. Total number that completed the questionnaire

University students	707
University academic staff	69
Secondary school students	460
Secondary school teachers	33

Although the authors will present statistical data for the survey questions of the four groups (Table 7), the main part of this section will focus on the quantitative data of the secondary school students and teachers (one small part of the larger project). It would be equally important to discuss the data of the university students and lecturers but the submission regulations has directed the authors to focus on more detailed discussion at this time for one group. Therefore the key question for this section is: *are these two groups responding to the same questions in the same way about aspects associated with engagement in science?*

DEMOGRAPHIC DATA OF THE SECONDARY SCHOOL PARTICIPANTS

Five secondary schools participated with 460 Year 12 students and 33 Year 12 science subject teachers completing the survey (see Table 3). The student size of the schools varied from 350 (Co-ed B) to 1600 (Boys single sex).

Table 3. Number of students and teachers participating in the survey and focus groups

	Y 12 Student Survey	Y 12 Student Focus Group	Y 12 Teacher Survey	Y12 Teacher Focus Group
Boys single sex	188	3	11	1
Girls single sex	97	2	9	1
Co-ed A	95	2	7	1
Co-ed B [low decile]	27	2	2	1
Co-ed C	60	1	4	1
TOTAL	460	10 (N = 51)	33	5 (N = 39)

Tables 4, 5, and 6 identify the nationality, the gender, and number of students studying the different disciplines in Year 12 respectively.

Table 4. Nationality of students and teachers in Year 12 (N = 493)

European / Pakeha	327
Maori (indigenous)	43
Pacific Islander	14
Other	109

NB Some students ticked more than one nationality

Table 5. Gender of students and teachers in Year 12

	Female	Male
Student	199	285
Teachers	16	17

Table 6. Number of students studying different science disciplines in Year 12

Agriculture / Horticulture	32
Biology	258
Chemistry	279
Physics	265
Science (all science disciplines)	29

Factor Analysis Data

A factor analysis of the four groups of participants for the two sets of questions identified five scales for questions 1-50 and three scales for questions 51-100 (Table 7). As noted above the first fifty questions placed an emphasis on extrinsic influences while the second fifty questions looked at intrinsic influences - student initiative.

Table 7. General description of the scales derived from the extrinsic and intrinsic influences questions

General description	Total number of questions involved in the scale	Cronbach's Alpha
Extrinsic influences		
Teacher qualities	9	.841
Students are challenged to develop meaningful understandings	5	.750
Students are encouraged to engage with science ideas and evidence	6	.735
Student's individual learning preferences are catered for	4	.754
Learning technologies are exploited for their learning potentials	4	.774
Intrinsic influences		
Commitment to high performance in science	10	.884
Learning science with excitement	7	.836
Developing meaningful understandings of science	5	.789

The scales of engagement

Student engagement in secondary school science is very complex and many factors influence the active engagement (Lyons 2003, Hipkins et al 2006, Tytler 2007, Osborne and Dillon 2008 and Panizzon and Westwell, 2009). The eight scales identified in the two sets of questions (Table 7) attest to the complexity. Analysis of the eight scales and their respective questions identified four scales that direct links to Tytler's (2003) effective classroom teaching components. In addition those four scales also focus on experiences associated with science, science ideas and the nature of science. Table 8 illustrates the links between the four scales of engagement and a corresponding component for effective classroom teaching, whereas three of the scales have links to the science / the nature of science experiences.

Table 8 Scales of the engagement questionnaire, effective classroom teaching components and the science ideas and nature of science

Scales of engagement component	Effective classroom teaching component (from Tytler, 2003)	Science ideas & nature of science
• Students are challenged to develop meaningful understandings	2. Students are challenged to develop meaningful understandings	nature of science notions
• Students are encouraged to engage with science ideas and evidence	1. The learning environment encourages active engagement with ideas and evidence	science ideas
• Learning technologies are exploited for their learning potentials	8. Learning technologies are exploited for their learning potentials	
• Developing meaningful understandings of science	2. Students are challenged to develop meaningful understandings	nature of science notions

Secondary students and teachers responses

If student's experience in science were important to engagement, one would expect both the students and teachers to recognize their importance. Therefore the frequency of responses by the teachers and students should be similar. Further analysis of the questions that make up each scale identified eight questions where there was a definite difference in the response betwen teachers and students. The frequency of the response to those questions is shown in Table 9.

Table 9. Frequency of response by teachers and students

Questions	Frequencies - percent (teachers / **students in bold**)				
	never	rarely	sometimes	often	always
Q21 My lecturers relate science to things that interest me	0 / **8**	0 / **18**	25 / **32**	63 / **35**	13 / **8**
Q47 I am asked to learn how science impacts people, society and technology	0 / **12**	18 / **24**	33 / **46**	36 / **13**	12 / **5**
Q11 I am asked to learn about how science relates to contemporary issues	3 / **7**	6 / **20**	44 / **56**	41 / **15**	6 / **2**
Q35 I am expected to plan the investigations that I undertake	6 / **6**	12 / **17**	48 / **29**	21 / **38**	12 / **10**
Q45 I am expected to use data/evidence to develop a logical scientific argument	0 / **5**	6 / **13**	31 / **37**	41 / **39**	22 / **6**
Q90 I consider ethical issues surrounding science	3 / **13**	16 / **20**	39 / **48**	39 / **13**	3 / **6**
Q74 I learn how scientific ideas have developed over time	0 / **7**	18 / **21**	42 / **52**	33 / **16**	6 / **4**
Q81 I learn about how science relates to contemporary issues	3 / **7**	16 / **20**	44 / **54**	34 / **16**	3 / **3**

The eight questions have been grouped according to the scales and reflect a difference in response from the teachers and students. The first question (Q21) sits within the ‘teacher qualities’ scale while the next two (Q47 and Q11) are grouped in the ‘students are challenged to develop meaningful understandings’ scale. Q35 and Q45 belong to the ‘ students are encouraged to engage with [science] ideas and evidence’ scale with the last three (Q90, Q74 and Q81) linked to the ‘developing meaningful understandings of science’ scale.

Seventy-six (76) percent of the teachers responded often / always to Q21 while only 43 percent of students responded in that manner. This difference in response may signal the ‘boring way’ science is presented (Hipkins et al, 2006). We also see a marked difference between teachers and students in Q47 and Q11. The teachers responded 48% for often / always in Q47 whereas just 18% of the students responded that way. A similar pattern emerges with Q11 – 47% of teachers and 17% of students responded as often / always. The lack of challenging experiences to develop understanding is evident in the students’ responses.

The two questions, Q35 and Q45, also show a difference in response. In Q35 the teachers appear to acknowledge that students are lacking the experience in planning their own investigations (66% response for never / rarely / sometimes) whereas the students do believe they are involved in planning their own science investigations (77% responded sometimes / often / always). Only 6% of the teachers responded never / rarely to Q45 whereas 18% of the students responded in a similar way. Perhaps as with Q35 students’ perceptions of what they are experiencing with science ideas and evidence are not based on a foundation of science understanding and cannot recognize the experiences.

The last three questions (Q90, Q74 and Q81) are part of the scale linked to intrinsic factors around personal development of meaningful understandings. The differences in teacher - students responses for often / always range from 42% - 18% in Q90, 39% - 20% in Q74 and 37% - 19% in Q81. With these three questions, teachers believe that that are providing the students with experiences but the results suggest otherwise.

CONCLUSION AND IMPLICATIONS

This paper has attempted to identify factors that influence the engagement and experiences of secondary science students. The perceptions of student engagement and experiences from the student and teacher were elicited via a questionnaire. The questions were designed to cover some of the complex interactions occurring in the classroom between the teacher and the student. Five scales were identified from the set of questions that focused on extrinsic factors. These five scales centre on the teacher – the personal qualities, their content knowledge and their pedagogical knowledge. The other three identified scales centred on student initiative or intrinsic elements of engagement. Four of the eight scales can be aligned with four components of Tytler's effective classroom teaching as well linking to the goals of science education in New Zealand.

There are specific questions from the different scales where significant differences occur in student - teacher responses. The questions align with Tytler's (2003) School Innovation in Science project, the recommendations of Osborne and Dillon (2008) and the focus on science experiences that are in real-life contexts.

The scales derived from the questionnaire do have implications for secondary school science teachers. Their importance is centred on the engagement or we would call active learning. The notion of the student becoming an active participant in their learning is at the heart of some of the student's responses but data indicates that the same cannot be said of the teacher's response. The authors would like to suggest that the questions be used to guide the classroom science teaching and learning, act as a guide to professional development in science departments / faculties as well as providing feedback to the teachers from the students. Differences in response from the teacher's and student's provide a starting point towards an interactive dialogue in teaching and learning and permits the student to take an active role in their engagement with science ideas, the nature of science and scientific literacy.

Although the focus of this paper used the questionnaire data from the secondary students and teachers to reach some conclusions about active learning and engagement in science experiences the project will be analysing the qualitative data from the focus groups to validate the assumptions made here and those made for the Year 1 students and their lecturers group. The authors anticipate that tertiary lecturers will use the responses of the students to modify their teaching and learning programme so as to assist students in making the transition from secondary to tertiary easier. Knowing where the students start and what thinking they bring with them to the university can be used to align existing tertiary science courses to meaningful science experiences.

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THE EFFECT OF GENDER AND CONTEXT ON USING WIRING DIAGRAMS AS A TOOL TO REVEAL STUDENT THINKING

James Mackay

School of Mathematics, Science and Technology Education, University of KwaZulu Natal, Private Bag X03, Ashwood 3605, South Africa

mackay@ukzn.ac.za

ABSTRACT

This paper reflects on the use of wiring diagrams as a tool to diagnose student problems in understanding electricity, as well as the gendered effect of context on the performance of students in designing wiring diagrams. Prior to wiring a model house, a sample of 161 primary school teacher trainees were taken through a series of activities designed to teach them basic electricity. They were then asked to design wiring diagrams for both a house as well as a model car. The wiring diagrams were then compared to the initial circuit designs and common errors were then categorised using accepted models of electric current. A smaller, selected sample was then interviewed about the process of designing wiring diagrams for both the cars as well as the houses. Initial findings indicate that students revert to earlier, less scientific models of electricity when confronted with the rather more difficult task of spatially organising the components that need to be connected to fit in with the design of the house/car. In addition, the interviews revealed that the context (house or car) affected female students' attitude and performance on designing a wiring diagram.

Keywords: *Context, conceptual change, gender, diagnostic tool, Electricity, Spatial Visualisation.*

INTRODUCTION

In researching students' conceptual ideas and their attitudes to current electricity tasks, this paper looks at learning basic electrical ideas through a contextualised project, that of wiring a model house. There has been much research into alternative conceptual frameworks in basic current electricity in the last three decades and most of this research has centred around the documentation of these alternative frameworks (Tasker and Osborne 1980; Shipstone 1988). In later years the focus has been on conceptual change strategies and ways to ameliorate particular alternative conceptual frameworks. Hewson (1999) in his paper on teaching for conceptual change, outlines a conceptual change approach to teaching physics that formed the basis of the course that was used as a research vehicle in this particular study. In the course in question, a basic electricity and electronics course for primary school design and technology teachers, I use a process based on work done by Hewson (1999), as well as earlier work done by Gilbert and Watts(1983), Tasker and Osborne (1985) and Shipstone (1988).

In the study I set out to find out what common errors are made when students draw circuit and wiring diagrams and what the possible effect of gender and context is in developing wiring diagrams from circuit diagrams? To do this, the sample chosen was a class of 161 second year design and technology students who were embarking on a single semester module on basic electricity and electronics for teachers. Table 1 below gives a brief profile of the educational background of the class a whole and who they are.

TABLE 1: Profile of the sample class – some statistics

67% female
20% have studied science at high school
55 % are from disadvantaged school background
40% training to be primary school teachers
Design & Technology students are generally not interested in science (physics in particular)

At the start it is important to notice that these are not science students (only 20% did science to the end of high school) and so in general the level of conceptual understanding regarding scientific ideas is not expected to be high. For this reason, the course uses a conceptual development approach (Hewson, 1999) to learning basic electricity.

The sample is also overwhelmingly female, which is to be expected since teaching in South Africa is mostly done by female teachers. (In fact this profile of the class accurately reflects the gender profile of education in South Africa in general. 55% of the class comes from what has been commonly termed a “disadvantaged educational background”. This has been determined using a government approved data base and ranking system which is determined by the relative wealth of the school itself (EMIS Report on School Disadvantage Indicators, 2006). No further attempt has been made to determine the extent of the educational disadvantage.

THEORETICAL UNDERSTANDING

This study draws on literature from three distinct but overlapping areas of Science Education Research. Grounding the study is the wealth of literature on alternative conceptual frameworks as well as conceptual change theory, with particular reference to learning electricity. Related to this I have also looked at issues on spatial visualization since students participating in the project are expected to visualise how a two dimensional circuit “fits” into a three dimensional house and also the conflict between Design and Technology on the one hand and Science on the other. Finally, I believe that there is some connection between the educational / home background of the students, their gender and their performance in design and technology tasks, particularly to do with visualising circuit diagrams in three dimensional spaces. This is played out in the tasks that were set for the students and their general belief in their own abilities to complete them. In the paragraphs below, I will try to link the literature from these seemingly different fields of research.

Electricity and Alternative conceptual frameworks

Understanding conceptual frameworks, especially in the field of physics education has been studied extensively in the past 30 years, Tasker and Osborne(1985) identified a number of different models that learners use in trying to make sense of electric current. These began with a simple *unipolar* approach that negates the need for a complete circuit, to a *dissipative* approach that sees current as a commodity that is being "used up" in the circuit. For learners to have any chance of success in this study, they will need to address their own conceptual frameworks while doing the task. Similar work has been undertaken by Shipstone (1988) and others who go further to developing diagnostic tests to identify such preconceptions. Arons (1981) documents a number of incorrect ideas that persist even after intervention, right until university study. The nature of these mental models that students employ are such that they hinder the conceptual development of any learning of current electricity.

Hewson (1999) advocates a conceptual change approach to the amelioration of alternative conceptions. In this approach he advocates addressing the preconceptions that the learners have through direct intervention using exercises and questioning that exposes preconceptions and puts the learner in a state of conceptual conflict. This approach, based heavily in constructivism is well known and has been used extensively in the teaching of physics in general. (Arons, 1981).

Since the basis of the module is conceptual change and conceptual development, it is important at this stage to outline my philosophy of conceptual development and conceptual change. The module focuses very much on learning to get circuits to work and so the fundamental idea of a circuit needs to be developed. Generally I start the module with a well known activity in learning electricity, where I provide each student with a piece of wire, a torch cell and a light bulb and ask the student to do what they can to light up the bulb. This has a dual effect, the first being that students very quickly work out that the Unipolar model of electric current and hence circuit design as identified by Osborne and Tasker (1985) in the early 80's simply does not work and that for the bulb to light, there need to be at least two connections.

The models of current used as a basis for interpreting circuit diagrams in this study are shown in table 2 below.

TABLE 2 Elementary Models of current (Shipstone, 1988)

Model	Description
Unipolar	Current from only ONE terminal (either positive or negative) No circuit, only a connection from the "power source" to the bulb
Clashing Currents	Both a "positive" as well as a "negative" current meet at the bulb and "clash" causing the bulb to light
Dissipative	Current is "used up" as charge moves around the circuit. Greater current near the (+) pole, dissipating further away from (+) / If negative charge is predominant, current "comes from" (-) pole
Scientific	Current is the same everywhere in a series circuit. For the bulb to light, there needs to be a completed circuit.

Science, Technology and Spatial Visualisation

The completion of the task in this study requires of the students that they visualise the flat 2-dimensional circuit that they have designed using learned scientific principles as fitting into a 3-dimensional space (either a car or a house). In order to do this, the student needs to be able to spatially represent the circuit, a process that requires more of a technological skill than a scientific one. Gilbert, Boulter and Elmer (2000) compare modes of representation commonly used in technology with those used in science. While both disciplines use visual representations like diagrams, Design and Technology makes greater use of concrete modes of representation such as physical scale models. The use of such models requires the learner to transition between 2-D and 3-D thinking in Design and technology much more than it does in science.

Being able to understand and create visual representations such as 3-D diagrams is a cognitive skill that is fundamental to performing well in both Science and Technology. While there has been considerable work done comparing spatial reasoning abilities across cultures, gender and class backgrounds, there has never been any concrete evidence to suggest that it is related to innate ability (Mitchelmore, 1980).The differential performance in science and technology between male and female learners has according to Mammes (2004) been attributed to greater familial encouragement given to boys and the tradition of boys playing games that require spatial abilities.

Issues of diversity - Gender and Educational Background

The differential performance and participation of boys and girls in Science and Technology has received considerable attention worldwide. This study follows from a previous study on the effect of gender and self efficacy on the performance of students on an electrical design and technology task (Mackay and Parkinson, 2010). In that study, it was found while female students were initially reluctant to wire a house and had low self efficacy levels for the task, they performed the same as the male students in the final assessment. There appeared to be no evidence for the effect of context on their performance. According to Lewis (1996), a context-driven approach to curriculum design is distinguished from a content-driven approach in that it takes social, environmental and physical contexts as starting points and uses these to move towards the theories, models and laws that are the starting point of a content-driven curriculum. This task uses the context of building a house to move towards a greater understanding of electrical circuits. Taking students' educational and home background into account, attitudes and levels of self-belief in being able to achieve a technology task are measured before, during and after the task, to see whether doing the task had a positive effect.

Atkinson (2006) found that female learners enjoyed design tasks. This is supported by Silverman and Pritchard (1996) who have shown that building houses is a task that is often favoured by female learners. Lewis (1996), however, points out, that such preferences may be a manifestation of the differential treatment afforded male and female children (including females' primary early socialisation from a parent of the same sex while males are usually socialised by parents of the opposite sex).

It is assumed in this study that differences in participation and achievement of female students in Technology and technological careers do not arise from ability differences, but from social attitudes viewing certain fields as less appropriate for women. These attitudes are embedded in the subtly different ways that male and female children are treated (Nicholson 1984, Smith and Lloyd 1978) and transmitted through discursive practices (Davies 1989).

Many school Technology tasks appear designed to be more interesting to boys than girls (Silverman and Pritchard 1996; Weber and Custer 2005). So it would seem that context is important when choosing a technology task that will be meaningful for girls as well as boys.

DESIGN OF THE STUDY

As mentioned earlier, this is part of a bigger and ongoing action research project where the same tasks are given every year to new students. The main task is the making and wiring of a model dolls house. The choice of a dolls house is elucidated in previous papers from the same study (Mackay and Parkinson 2009 and 2010).

This paper asks two questions.

1. What are the common errors made in drawing circuit diagrams and related wiring diagrams?
2. What is the significance of these errors from a conceptual learning point of view, a spatial visualization point of view and a gender and educational background point of view?

Approach to teaching

There were a number of features to the teaching of this course which are itemized below.

1. *Contextualised Teaching:* The use of a dolls house and a car as two contexts was deliberate in order to see the effect of context on performance in the tasks of drawing circuit and wiring diagrams.
2. *Teaching for Conceptual change:* The fundamental concepts of basic current electricity were taught in such a way that learners were made aware of their conceptual ideas and where change was necessary; they were led to develop their own conceptual frameworks. All conceptual models were tested by the students with their own apparatus. Alternative conceptions were identified and given a name.
3. *Addressing Issues of gender and self Efficacy:* Groups were single sex in order to allow female students to participate to a greater extent than in other classes. Tasks that female students enjoyed (Decorating, making the house) were integrated with tasks they did not enjoy (Connecting circuits, soldering). Students self efficacy was developed by helping students develop their technical skills.
4. *Technology vs. Science:* After developing an initial scientific understanding of electrical concepts, the focus was on getting the circuit to work inside the house and on the necessary design skills. To do this, a wiring diagram had to be developed from the planned circuit diagram.

DATA COLLECTED

While this was in fact part of a much larger study that included data on self efficacy as well as conceptual development and attitude, this study drew on only two data sources.

Drawings of Circuit and Wiring Diagrams

The first was the analysis of wiring and circuit diagrams drawn by students and the second were follow up interviews with students on instances regarding wiring diagrams and conceptual frameworks that they use for predicting and analysing circuits. These data were firstly used to compile a catalogue of common errors in drawing both wiring diagrams and circuit diagrams and then used to probe the effect of context (house or car) on the production of wiring diagrams.

Interviews

Eight students (all female) were interviewed on the tasks they were given. They were selected as interesting candidates because of the diagrams they had drawn. They were then interviewed in an open ended manner in order to elicit their thinking behind why they drew the diagrams they did as well as the relative difference in difficulty between the house task and the car task. The interviews were recorded and then transcribed.

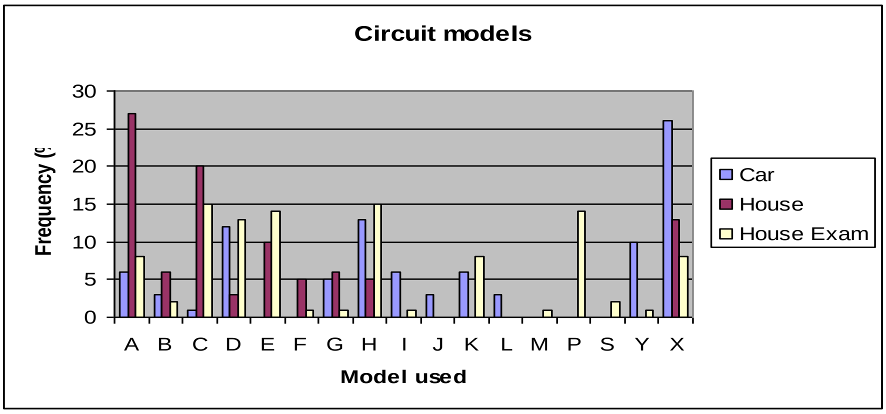
MAIN FINDINGS

Common Errors

Generally, students were happy to draw circuit diagrams and had in fact learned to do this fairly competently, one assumes as a result of the programme of study prior to the final task given. The drawing of wiring diagrams presented some difficulty to a number of the students in the module, as outlined by table 3 which records the relative frequency of the common errors made. The catalogue and analysis of common errors in the drawing of wiring diagrams as well as circuit diagrams is listed below:

Error Frequency

The frequency of these errors is shown in the histogram below, which also distinguishes between the context in which the errors were made. Students were asked to draw both circuit and wiring diagrams for both the house and the car. There were also several questions on circuit diagrams as well as a wiring diagram for a house in the final examination and the relative frequency of these errors in the examination is also recorded. The meanings of each model used are indicated in table 3.



Specific frequencies of the errors found are given in table 3 below

Table 3: Ranking common errors by total frequency

	Context				
Common Error	Car	House	House Exam	TOTAL	Description of Common Error
A	6	27	8	41	Unipolar thinking used when drawing the wiring diagram (WD)
C	1	20	15	36	Short circuit wires present in the CD
H	13	5	15	33	Simple series connection portrayed as WD
D	12	3	13	28	Components "left hanging" in the WD (perhaps as a result of unipolar thinking)
E	0	10	14	24	Short circuit wires in the WD
K	6	0	8	14	Non functional loops in the circuit (A version of the short circuits)
P	0	0	14	14	No power in the circuit
G	5	6	1	12	Wiring follows house layout (spatial visualization problems)
B	3	6	2	11	Draws the Circuit Diagram (CD) as the wiring diagram (WD)
I	6	0	1	7	Draws the WD as the CD
F	0	5	1	6	Main switch in parallel with the battery (A version of the short circuiting)
J	3	0	0	3	WD more accurate than CD
L	3	0	0	3	Parallel CD / Series WD (Same as H above but with a definite difference)
S	0	0	2	2	Switches for parallel circuit wrongly placed.
M	0	0	1	1	More than required connections to lamp / component
Y	10	0	1	11	Other mistakes
TOTAL					
X	26	13	8	47	Did not complete

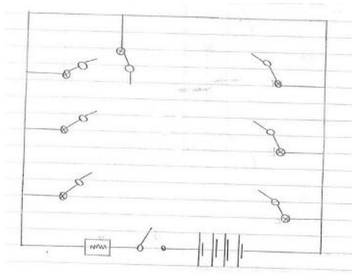
Interpretation of Common Errors

These data will be interpreted in two ways. The first is to simply look at all the errors that were made in all three tasks and try to link them with other errors and then find ways to interpret the thinking behind them. This was to be supported by the interviews, but in the end, the interviews only provided us with some insight into the attitude the students had with different tasks. This will be discussed later.

The second interpretation is to compare the performance on the three different tasks. As can be seen from the graph and table, the contexts of house and car affected the students' performance. For this, interview data was helpful in ascertaining the reasons for this differential performance.

Trend 1: Unipolar wiring Diagrams; Completed circuit diagram(A)

Apart from those students who did not complete the task, all students other students provided a completed circuit as their circuit diagram. This is not surprising as gave as a circuit diagram the correct parallel circuit. In drawing this circuit, they correctly drew the positions of the power source used, the switches and the components (lights and motors). It is clear that when it comes to drawing the wiring diagram, students revert to previously held unipolar ideas about how circuits work. This is the most common error when it comes to the wiring diagram of the house, which was a major project on the course. What is interesting is that this is not the most frequent error in the similar task, the wiring of a car. Here, the most frequent error is H, the use of a simple series circuit in drawing the wiring diagram.



Trend 2: Fewer errors in the car diagram of error A and error C

The car task came after the house task and perhaps there was an improvement if there were fewer errors, however, the large number of those students who did not complete the task indicates that this is probably not the case.

Trend 3: A greater number of students did not complete the car task than the house task

This is put down to the context being different. Essentially, the task was the same nd called for the same parallel circuit to be designed into the space of a car in this case and not a doll house. This could easily be due to lower levels of self efficacy amongst female students. Of the eight students that were interviewed, all were female and all but one expressly indicated that the fact that the context was a car made the task difficult or impossible. The one female student who indicated that the context did not matter, described herself as a "tomboy" who loved "boys games. She described her social and sporting life as being mainly to do with action oriented "boys things" Interestingly, the house she chose to design for the house task was a fire station.

Common responses to the car task were:

"This is impossible – how do we know about cars. This is for boys"

“I found it difficult, because I don’t know about cars, I am a girl”

Trend 4: Drawing the correct parallel diagram for the circuit, but a unipolar design for the wiring diagram.

This was to be found in both the house task as well as the car task. Four such examples are shown below.The interviews did not reveal anything definite, except that all agreed that drawing the circuit was easy, but “putting it into the house / car” was hard. The students had all managed to design an appropriate circuit and connect it on a flat table, but the three dimensional visualization necessary for designing the wiring diagram appeared to be too hard.

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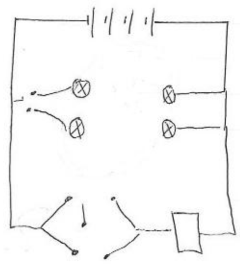
Example 1

D Components left hanging / unipolar model (car)



In this example, components are left hanging. This is an interesting circuit, because the power is in fact connected to the components. One component is connected in a “circuit –like” loop, with the bulbs connected in a unipolar fashion. This student simply could not explain why they drew it like this

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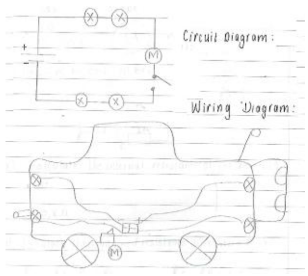
Example 2

A: Unipolar wiring diagram (car)



This is an example of a unipolar wiring diagram for the car task. The circuit diagram is wrong of course. It should be a parallel circuit, but one can clearly see the unipolar nature of the wiring diagram

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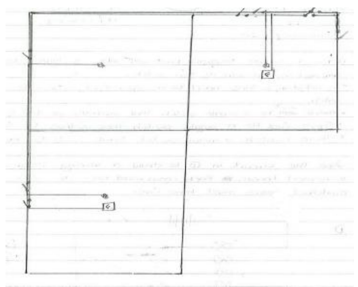
Example 3

A: Unipolar wiring diagram (house)



This is a clear use of the unipolar model in drawing the wiring diagram for a three roomed house.

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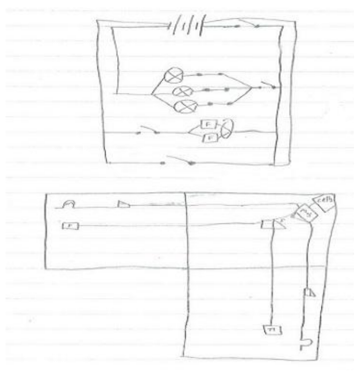
Example 4

A: Unipolar wiring diagram (house)



This example clearly shows a parallel circuit which also incorporates an unnecessary short circuit across the terminals of the battery. The wiring diagram for the same circuit is also unipolar by design

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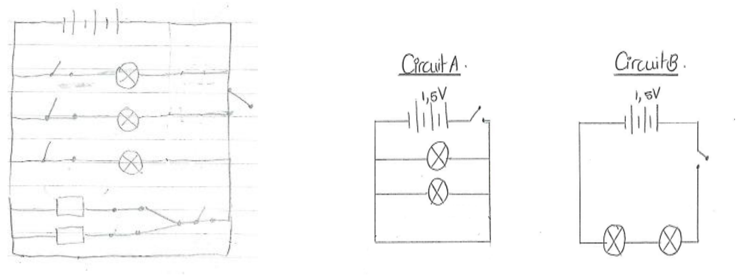
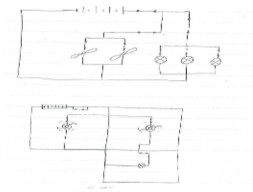
Trend 5: Short circuits

This is shown in common errors C, E, K and F. In these instances which have been separated, there are inexplicable short circuits drawn into the mainly the circuit diagrams, but also the wiring diagrams on occasion (E). The interviews revealed no reason for this, except one student remarked that it made the circuit “neater”. An example of this error is shown below.



Trend 6: Reverting to a simple series circuit when drawing the wiring diagram.(H)

This error was also relatively common. In the example shown below, a student has drawn the correct parallel circuit for the circuit diagram (although standardized component symbols have not been used). This has led however to a much simpler version of the wiring diagram, a series circuit. Although the series circuit will work, it is not a good design and also not the same circuit that this student actually used in the wiring of the house. The student wired the house correctly with a parallel circuit, but was unable to integrate the parallel circuit into the spatial representation of a three roomed house.



Trend 7 Using the circuit diagram as the wiring diagram (B)

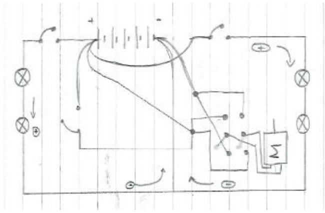
This I think is also a consequence of poor spatial reasoning and development. Although this was not confirmed by the interview data.

Trend 8 No power source in the circuit

This was a minor error. Sometimes the circuit was correct, except for the fact that there was no power connected.

Trend 9: Use of the clashing currents model(car)

This wiring diagram for a car clearly shows how the student has designed the circuit with regard to the movement of charge in the circuit. This is best described in terms of the clashing currents model.



DISCUSSION

Students showed poorer performance in developing wiring diagrams than circuit diagrams, along with regression to unipolar models of design as well as (in fewer cases) simple series circuits, suggesting that when students are asked to plan a circuit spatially, they retreat to models of thinking that we as teachers believe they have "left behind". This could be related to poor spatial visualisation that has been found in other literature to be common in non-science majors and learners from educationally disadvantaged backgrounds.

Interviews with selected female students who drew wiring diagrams suggest that context has an effect on whether or not female students feel able to design circuit and wiring diagrams. This is supported by evidence from similar tasks given where the circuit remained the same, but the context was changed. Female students reported that they felt less able to design a wiring diagram for a car. It was seen as a male domain.The pattern of errors for the car wiring diagram was different from the house wiring diagram, suggesting that students (predominantly female) found this more difficult than they did for the house. Low self efficacy levels amongst female students in terms of spatial visualisation could have led to regression to unscientific thinking when it came to designing the wiring diagrams.

In conclusion, the wiring diagram is a useful diagnostic tool for eliciting "hidden" non scientific ways of thinking as well as addressing issues of spatial visualization, context and gender in the learning of electricity.

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LATIN-AMERICAN PROJECT OF EVALUATION OF ATTITUDES RELATED TO SCIENCE, TECHNOLOGY AND SOCIETY (PIEARCTS): PRACTITIONER TEACHER THINKING

María Antonia Manassero-Mas
University of the Balearic Islands, Spain
ma.manassero@uib.es

Ángel Vázquez-Alonso
University of the Balearic Islands, Spain
angel.vazquez@uib.es

Antoni Bennàssar-Roig
University of the Balearic Islands, Spain
abennassar@uib.es

ABSTRACT

This paper describes the Latin-American Project on the Evaluation of Attitudes Related to Science, Technology, and Society (PIEARCTS), an international cooperative educational research aimed to evaluate students' and teachers' beliefs on STS issues, as a central part of scientific literacy for all. This general aim unfolds into identify the strengthens, the weaknesses and the necessities, which influence STS learning, as well as to improve the teaching and learning of STS issues through the planning, the design and the innovation of science curriculum, and teacher training. As an illustration of the evaluation aim, the STS thinking of teachers from scientific and non scientific specialties is presented. The results show neutral, lightly positive global attitudes, and the detailed analysis allows identifying the teachers' positive and negative beliefs. The comparisons between science and arts teachers show that science teachers' attitudes are just slightly better than those of the art teachers, yet lacking statistical signification. The implications of these results for the teaching of the nature of the science and technology and for the training of science teachers are discussed.

Keywords: *nature of science and technology*, *science-technology-society, scientific and technological literacy, attitude evaluation, teacher thinking.*

INTRODUCTION

Scientists, educators and international organizations of education in science and technology (S&T) agree that the learning and development of informed and appropriate conceptions on S&T and their relationships to society (STS), so called nature of science and technology (NoS&T) topics, is an essential indicator of S&T literacy for all (Lederman, 1992).

The nature of science and technology (NoS&T) is a meta-cognition that arises from the reflections of philosophers, sociologists and historians, scientists, teachers and experts in science education. The core of this reflection embraces quite different issues although they can be summarized as what science is, how it internally works, how it is developed, how it builds knowledge, how it relates to technology and society, what values scientists use in their work, etc. (Acevedo, Vázquez, Manassero & Acevedo, 2007).

A great amount of research has examined pre-service and in-service science teachers' NoS&T conceptions in the last years. The studies consistently report that teachers possess inadequate conceptions of NoS&T, which are inconsistent with modern views of science and scientific practice. They suggest that teachers do not understand NOS, and they show large proportions of teachers holding traditional positivistic, idealistic views of science and technology and their interactions within society. For example, many teachers believe that scientific knowledge is not tentative, conceptualize science as a body of knowledge or identify science with a discipline (physics, chemistry or biology), portray technology as applied science, conceptualize scientific hypotheses, theories and laws in a developmental sequence, etc. (Abd-El-Khalick & Lederman, 2000; Abell & Smith, 1994; Gallagher, 1991; Haidar, 1999; Hammrich, 1997; King, 1991; Lederman, 1992; Lederman, Schwartz, Abd-El-Khalick & Bell, 2001; Pomeroy, 1993). Most of the research on teachers' conceptions of NoS&T has been focused on secondary and pre-service science teachers rather than on primary, university, in-service or non-science teachers.

The Latin-American Project of Evaluation of Attitudes Related to Science, Technology and Society (Spanish acronym, PIEARCTS) is an international cooperative investigation (http://www.piearcts.com.ar/) that aims to diagnose the students' and teachers' beliefs and attitudes on STS topics in seven Latin-speaking countries (Spanish and Portuguese). The PIEARCTS planned sample embraces three main groups: students in their last year of high-school or first year of college (18-19 year-old), undergraduate students in their last year, with special attention to those involved in pre-service teacher training (22-23 year-old), and practitioner teachers in primary, secondary and higher education.

This paper depicts the practitioner teacher's NoS&T conceptions, which are assessed applying a paper and pencil questionnaire to a large sample of teachers from science and non-science (art) backgrounds. The research questions are twofold: Which are the strengths and weaknesses of practitioner teachers' thinking on NoS&T? Is practitioner science teachers' understanding on NoS&T better than their counterpart practitioner art teachers?

Table 1. Dimensions of science and technology issues that develop the 30 COCTS items applied through the two instruments (form 1 and form 2).

Dimensions	Form 1 Items (key / issue)	Form 2 Items (key / issue)
a) Definition of science and technology	F1_10111 science	F2_10211 technology
	F1_10411 interdependence	F2_10421 interdependence quality of life
b) Science – Technology – Society Interactions	F1_30111 STS interaction	
Influence of society in S&T	F1_20141 country's government policies	F2_20211 industry
	F1_20411 ethics	F2_20511 educational institutions
Influence of S&T in society	F1_40161 social responsibility contamination	F2_40131 social responsibility information
	F1_40221 moral decisions	F2_40211 social decisions
	F1_40531 life welfare	F2_40421 Application to daily life
		F2_50111 union two cultures
Internal Sociology of science	F1_60111 motivations	F2_60521 gender equity
	F1_60611 women under representation	F2_70211 scientific decisions
	F1_70231 consensus decisions	F2_70711 national influences
	F1_80131 advantages for society	
c) Epistemology	F1_90211 scientific models	F2_90111 observations
	F1_90411 tentativeness	F2_90311 classification schemes
	F1_90621 scientific method	F2_90521 role of assumptions
		F2_91011 epistemological status

METHOD

Sample

The sample involves 822 practitioners teachers, who belong to all educational levels (primary, secondary and university), science-technology and art specialties, men and women, and represent an approximate population of 42000 practitioners. About 72% of teachers have got a science or engineering specialty, (28%, arts or humanities), 59% are men (41% women). The overall sex distribution varies depending on the group, as science group displays 74% men, while the group of humanities just has 41% men. The teachers' age spread from 23 to 76 year-old. The teachers answered 30 COCTS items distributed in two questionnaire forms (to let the response time maneagable) that were ramdomly applied to the whole sample by halves; so that 390 teachers validly answered the form 1 and 432 teachers answered the form 2.

Instrument

The PIEARCTS uses the Questionnaire of Opinions on Science, Technology and Society (Spanish acronym, COCTS), an empirically developed pool of 100 multiple-choice questions, credited as one of the best paper and pencil instruments to evaluate STS beliefs as its empirically developed construction warrants the item validity (Aikenhead & Ryan, 1992; Rubba, Schoneweg & Harkness, 1996). The STS topics are structured into the following COCTS dimensions (table 1): Definitions of S&T, external sociology of S&T (influences of Society on S&T, influence of S&T on Society), education in S&T, internal sociology of S&T, and epistemology.

The items display a general multiple choice format. Each item stem presents a specific NoS&T issue using a common and simple language within a non-technical style (table 2). A variable number of sentences, each labelled with a letter A, B, C…, follow the stem text; each sentence states a particular reason that explains a position (belief) on the stem issue (Manassero, Vázquez & Acevedo, 2003).

Table 2. Text of the item 40211 that addresses the issue about the decision maker on social issues related to science and technology (Influence of S&T in society).

40211 Scientists and engineers should be the ones to decide what types of energy our country will use in the future (for example, nuclear, hydro, solar, or coal burning) because scientists and engineers are the people who know the facts best.
Scientists and engineers should decide: A. because they have the training and facts which give them a better understanding of the issue. B. because they have the knowledge and can make better decisions than government bureaucrats or private companies, both of whom have vested interests. C. because they have the training and facts which give them a better understanding; BUT the public should be involved — either informed or consulted. D. The decision should be **made equally**; viewpoints of scientists and engineers, other specialists, and the informed public should all be considered in decisions which affect our society. E. The **government** should decide because the issue is basically a political one; BUT scientists and engineers should give advice. F. The **public** should decide because the decision affects everyone; BUT scientists and engineers should give advice. G. The **public** should decide because the public serves as a check on the scientists and engineers. Scientists and engineers have idealistic and narrow views on the issue and thus pay little attention to consequences. H. It **depends** of the type of decision; it is not the same thing to decide on the nuclear disarmament or on a baby. In some cases the scientists could make the decision, but in other, the citizens or the stakeholders should make it.

Some 30 items is drawn from COCTS by the PIEARCTS research team after a consensus process to design the two forms (F2 and F2) applied to teachers. The main design criteria of questionnaires were a balanced coverage of the COCTS dimensions and a manageable answering time for surveyed people. Some reliability indexes of this application will be produced in the Symposium.

Procedures

The questionnaire forms were answered by teachers through a self-administration process by means of a web-resident application. The participants are not asked to choose any of the multiple choice statements, rather they are asked to rate their agreement (1, total disagreement; 9, total agreement) on each item statement (called the multiple response model). These agreement direct scores are transformed through a scaling metric described elsewhere (Vázquez & Manassero, 1999; Vázquez, Manassero & Acevedo, 2005) into homogeneous attitudinal-belief indexes (-1, +1), which are invariant across all sentences, categories and items. The index meaning states that the higher (lower) the index, the higher (lower) the belief's appropriateness according to the current knowledge from history, philosophy and sociology of S&T.

The indexes are quantitative parameters that allow computations and the application of inferential statistics for hypothesis testing, which can be applied to compare groups or to set up cutting points for levels of achievement in index scores (Vázquez, Manassero & Acevedo, 2006). To this aim the effect size of the differences (differences measured in standard deviation units) is applied along with a criterion to achieve relevance (size of the difference higher than a third of the average standard deviation). The difference between groups is considered relevant when its effect size is higher than .30 (of course, the relevant differences are almost always statistically significant, $p < .001$).

The NoS&T attitudes and beliefs on each item are computed as a weighted mean of their statement indexes allowing to get the most positive, the most negative, and the neutral beliefs, which identify the strengths and weaknesses of the NoS&T thinking on each issue. This is a very useful information to improve teacher training on these issues.

RESULTS

The global average of the 30 applied items for the whole sample of teachers (m = .0199; SD = .273) is roughly a null value. This parameter is interpreted as a neutral global attitude for the teachers on the whole STS issues represented by the set of 30 applied items. The positive beliefs are compensated with the negative ones to produce this approximately neutral average for the whole sample, which suggests that some informed beliefs cohabit with less informed ones, yet overall are not positive (table 3).

Each items' global index is the most specific general indicator of teachers' positions on the diverse NoS&T topics outlined in each of the 30 items. The items' indexes display somewhat balance between positive and negative values, as the same number of items approximately display positive and negative values. This is the first indicator of balance among positive and negative visions which produces the whole neutral disposition (table 3).

The items displaying the best (highly positive) or the worse (highly negative) indexes are identified through the application of the effect size criterion in relation to zero score. Applying this approach, the following items have got the best (more positive) indexes (in descending order):

F1_40161 Social Responsibility contamination
F1_30111 STS Interaction
F2_50111 Union two cultures
F2_20511 Educational Institutions

F2_60521 Gender equity
F1_10411 Interdependence
F2_40131 Social Responsibility Information
F2_10421 Interdependence Quality of life
F1_10111 Science
F1_20141 Government politics a country
F1_40221 Moral Decisions
F1_60611 Women under representation
Applying the same effect size criterion, the following items have got the most negative indexes (in descending order):
F2_70211 Scientific Decisions
F2_10211 Technology
F1_20411 Ethics
F2_40421 Application to daily life
F1_40531 Life Welfare

Table 3. Global mean indexes of the 30 items for the whole sample of surveyed teachers sorted by their mean value.

Form 1 / 2 – Item number - issue	N	Mean	Std. Deviation
F1_40161 social responsibility contamination	371	0,327	0,216
F1_30111 STS interaction	365	0,317	0,304
F2_50111 union two cultures	393	0,210	0,250
F2_20511 educational institutions	412	0,195	0,227
F2_60521 gender equity	390	0,167	0,214
F1_10411 interdependence	388	0,161	0,289
F2_40131 social responsibility information	408	0,140	0,212
F2_10421 interdependence quality of life	423	0,130	0,194
F1_10111 science	390	0,124	0,200
F1_20141 government politics a country	379	0,110	0,216
F1_40221 moral decisions	370	0,109	0,255
F1_60611 women under representation	366	0,093	0,250
F1_70231 consensus decisions	364	0,041	0,290
F2_70711 national influences	390	0,034	0,298
F1_90411 tentativeness	361	0,025	0,294
F2_40211 social decisions	402	-0,001	0,293
F2_20211 industry	415	-0,002	0,350
F2_90111 observations	387	-0,031	0,385
F1_80131 advantages for society	367	-0,042	0,252
F2_90311 classification schemes	387	-0,044	0,260
F2_90521 role of assumptions	386	-0,045	0,344
F1_60111 motivations	366	-0,065	0,236
F1_90211 scientific models	362	-0,069	0,321
F2_91011 epistemological status	386	-0,072	0,276
F1_90621 scientific method	367	-0,086	0,250
F2_70211 scientific decisions	390	-0,096	0,281
F2_10211 technology	432	-0,187	0,227
F1_20411 ethics	372	-0,231	0,358
F2_40421 application to daily life	398	-0,279	0,268
F1_40531 life welfare	369	-0,336	0,387

On the other hand, the questionnaire and the method allow inferential statistics, whose power could be illustrated through the comparison between science and art teachers. Taking into account the different background specialization on S&T between science and art teachers it should be hypothesized that science teachers would show significantly better NoS&T understanding than art teachers, that is to say, science teachers' indexes would be significantly higher than art teachers' indexes.

Nevertheless, the most remarkable finding of this overall comparison on the mean item indexes of both groups shows that both appear more equal than different (table 4), contradicting the former hypothesis. Only one out of 30 items (the item about moral decisions) displays an effect size between the groups higher than the minimum cutting point (> 0.3) to be considered a relevant difference; the remaining 29 items display effect size scores that get positive and negatives values, although they can not be deemed significant enough for relevance.

The overall comparison among groups shows that science teachers' conceptions tend to be better than their art counterparts, who lack scientific training, yet the differences between the two groups are not statistically relevant. Thus, in spite of the deeper enculturation in S&T of science teachers, the results can not allow for claiming that science teachers' understanding of NoS&T be significantly better than art teachers' understanding.

Furthermore, this empiric method also allows unveiling some specific NoS&T issues where the art teachers exhibit more appropriate attitudes than science teachers (8). The presence of eight negative effect size item scores means that art teachers over score science teachers in these items, that is to say, science teachers' beliefs are worst than art teachers in these NoS&T specific issues.

The 8 items in the bottom of table 4 account for those issues where art teachers' indexes are better than science teachers. Curiously, half of these items (4) belong to the epistemology dimension, deemed crucial for understanding some key features of S&T; the epistemology dimension is the most representative of the intrinsic values of S&T as a way of knowing and crafting the natural world. So, art teachers display better understanding in a significant number of epistemology items, which represent more than half of the whole epistemology items (7) teachers answered in the questionnaires.

Table 4. Global mean indexes of the 30 items for the groups of science and art teachers sorted by its effect size value.

Form 1 / 2 – Item number - issue	Science	Art	Effect size
F1_40221 Moral Decisions	0,138	0,038	0,384
F1_80131 Advantages for society	-0,021	-0,094	0,289
F1_60111 Motivations	-0,047	-0,108	0,258
F1_20141 Government politics a country	0,125	0,073	0,230
F1_90621 Scientific Method	-0,069	-0,126	0,224
F1_20411 Ethics	-0,209	-0,287	0,215
F1_60611 Women under representation	0,106	0,059	0,189
F1_40161 Social Responsibility contamination	0,339	0,297	0,189
F1_10411 Interdependence	0,177	0,122	0,187
F1_40531 Life Welfare	-0,315	-0,386	0,180
F1_30111 STS Interaction	0,328	0,289	0,127
F1_10111 Science	0,130	0,109	0,105
F1_70231 Consensus Decisions	0,044	0,032	0,042
F2_70711 National influences	0,045	0,005	0,033
F2_20511 Educational Institutions	0,202	0,175	0,028
F2_10421 Interdependence Quality of life	0,135	0,116	0,024
F2_90521 Role of assumptions	-0,037	-0,070	0,023
F2_60521 Gender equity	0,171	0,156	0,018
F2_40131 Social Responsibility Information	0,143	0,132	0,012
F2_10211 Technology	-0,184	-0,194	0,010
F2_70211 Scientific Decisions	-0,094	-0,102	0,007
F1_90411 Tentativeness	0,026	0,024	0,007
F2_50111 Union two cultures	0,209	0,211	-0,002
F2_90311 Classification Schemes	-0,045	-0,041	-0,004
F1_90211 Scientific Models	-0,070	-0,066	-0,013
F2_91011 Epistemological Status	-0,078	-0,056	-0,021
F2_20211 Industry	-0,011	0,023	-0,025
F2_90111 Observations	-0,055	0,042	-0,062
F2_40421 Application to daily life	-0,299	-0,221	-0,072
F2_40211 Social Decisions	-0,028	0,078	-0,092

Summing up, the comparison between science and art teachers displays the surprising finding that science teachers do not clearly beat art teachers on understanding NoS&T as could be expected, taking into account their higher enculturation in S&T. Yet, art teachers overscore science teachers in some (8) out of 30 items.

DISCUSSION

This paper describes the general in-service teacher thinking about some NoS&T issues, which is an absolute assessment of teachers' understanding, and a comparison between science and non science teachers, an unusual and relative assessment in science education, which is mostly focused in science teachers (Akerson & Volrich, 2006). Teacher thinking is assessed by means of a wide paper and pencil instrument and a sophisticated quantitative procedure that allow quick applications to large samples and performance of inferential statistical analysis for hypothesis testing (Vázquez, Manassero & Acevedo, 2005, 2006).

Although one would expect that teachers would show positive indexes overall items, this is not the case in these results. The first finding highlights the overall teachers' poor understanding about NoS&T issues. The score indexes along the 30 issues in NoS&T items spread from positive to negative displaying a kind of symmetrical balance among them and lower scores than expected, when positive. Just a bunch of items (11 items, about 33%) display positive indexes (low scores), which could be deemed an acceptable low adequate understanding of NoS&T, while the big majority of items represent an insufficient negative understanding of NoS&T; further, any of the the highest indexes are actually high.

The teachers' weaknesses, which agree with other studies, (Bell, Lederman & Abd-the-Khalick, 1998; Akerson & Volrich, 2006; Khishfe & Abd-the-Khalick, 2002), point out to the specific NoS&T contents to be included in science teacher training on NoS&T to improve teachers' understanding of NoS&T. When considering only the science teacher group, eliminating the art teachers, the previous coments remains almost the same and valid.

Overall, it should be expected that science teachers' indexes would be significantly higher than art teachers' indexes, given the higher background specialization on S&T of science teachers when compared with art teachers, who lack scientific training. Although the second and most important finding underlines that science teachers' NoS&T conceptions tend to be better than their art counterparts, the mean item index differences between science and art teachers are not statistically relevant. This lack of signification suggest that science and art teachers appear more equal than different, so the commonsense expectation about the superiority of science teachers could be considered empirically falsified. In spite of the deeper enculturation in S&T of science teachers, they do not significantly exhibit better understanding of NoS&T.

An straightforward interpretation of this equality between science and non-science could suggest that the scientific training delivered to S&T teachers through undergraduate canonical lessons, practical work and scientific inquiry is not effective to achieve more appropriate NoS&T conceptions than art teachers (Lederman, 1999). This interpretation has direct and urgent implications for teacher training nowadays: as the science education renovated curricula and current research aim to achieve the scientific and technological literacy for all, and NoS&T is a key component of literacy, teachers must be well trained to teach NoS&T (Duschl, 2000; Schwartz, Lederman & Crawford, 2004).

These findings want also to illustrate researchers about the power of the methodology based on COCTS items applied in the PIEARCTS project. The empirical quantitative method produces attitudinal invariant standardized item indexes, which diagnose the teachers' strengthens and weaknesses on NoS&T conceptions and understanding, as well as to perform statistically hypothesis testing in group comparison and more wide comparisons such as comparisons among different research studies that qualitative methos do not allow at all.

All in all, the main finding suggests that the undergraduate scientific education is not effective for graduates in S&T to learn and understand appropriate ideas on NoS&T issues. This claim points out a prospective aim for teachers: the undergraduate education and the specific initial science teacher training must be deeply innovated including effective NoS&T teaching to facilitate the acquisition of informed views on NoS&T the teachers.

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CHEMISTRY STUDENT TEACHERS ` BELIEFS ABOUT TEACHING AND LEARNING DURING THEIR TEACHER EDUCATION PROGAM – A CROSS-LEVEL STUDY

Silvija Markic

University of Bremen, Germany

smarkic@uni-bremen.de

Ingo Eilks

University of Bremen, Germany

ingo.eilks@uni-bremen.de

ABSTRACT

This paper presents a cross-level approach researching German chemistry student teachers` beliefs about teaching and learning. The study is based on student drawings which show commonplace teaching situations. These drawings were analyzed with an evaluation pattern which was developed using Grounded Theory. The pattern included three qualitative scales: beliefs about classroom organization, teaching objectives, and epistemological beliefs. This paper compares the beliefs found within different groups of student teachers at different stages of their teacher training program. The data presented here was taken from freshman student teachers, student teachers in the middle of their teacher training program, and student teachers in compulsory in-service training, which occurred after the participants had finished their university program. Each group was composed of circa 30 student teachers. The results suggest that freshman student teachers profess more traditional beliefs about chemistry teaching and learning that are characterized e.g. by teacher-centeredness and receptive learning. Chemistry student teachers halfway and all the way through their teacher education program at the university level hold more modern beliefs about teaching and learning. Comparing these two groups, the first group's beliefs seem to be the most strongly modern in character. Implications for teacher education are also addressed.

Keywords: *Chemistry Student Teachers` Beliefs, Cross-Level Study, Chemistry Teacher Training Program, Grounded Theory*

INTRODUCTION

In recent decades science education research has focused more and more on (student) teachers` beliefs. We know that educational reform will only succeed if teachers` beliefs, their knowledge and their attitudes are taken seriously into account and correspondingly incorporated into reform efforts (Nespor, 1987). Bandura (1986) stated that beliefs tend to be the best indicators for one's personal behavior. Koballa, Gräber, Coleman, and Kemp (2000) concluded that beliefs influence all types of interactions between teachers and pupils. Although there has been - up until now - little evidence giving a clear picture of the relationship between a teacher's beliefs and her/his actions and impact on students' learning, there is a consensus among researchers that teachers' beliefs permanently influence their teaching practice (Clark and Peterson, 1986). Thus, many scholars view knowledge about teachers` beliefs as crucial when attempting to affect teachers' actions, including their beliefs concerning both teaching and learning (e.g. Ben-Peretz, 1984; Fischler, 2000).

Pajares' review from 1992 illustrates that beliefs play a crucial role in defining personal behavior and in organizing knowledge and information. Taking this one step further, we can assume that student teachers` beliefs affect both their learning and their understanding of teaching through every step of their teacher education program (Fischler, 2000).

In our understanding, teachers' beliefs' are a weak but inclusive construct which covers any mental predispositions a teacher or student teacher holds and which affects his/her behavior in classroom situations. These beliefs stem from personal experience, knowledge or social background (Markic, 2008; Markic, Valanides & Eilks, 2008).

Some research on science student teachers` beliefs and the differences between teachers from different scientific disciplines is already available (see e.g. in Markic & Eilks, 2008). Tsai (2002) categorized student teachers' beliefs about teaching, learning, and science as traditional, process-oriented, or constructivist. The results of his study show that the majority of 37 Taiwanese science teachers held traditional beliefs. More importantly, over half of these student teachers held beliefs about teaching, learning and science that were closely aligned to each other. Koballa et al. (2000) described German chemistry student teachers' beliefs as reproductive rather than constructive. Boz and Uzuntiryaki (2006) found that the majority of twelve Turkish chemistry student teachers held intermediate beliefs (transitional between traditional and constructivist) about teaching. Simmons et al. (1999) also showed that beginning teachers hold a wide variety of beliefs about teaching (teacher-centered, student-centered and/or conceptual) and that these beliefs are not very stable. Nevertheless, such beliefs were found to be not fully developed or clearly reflected in many instances.

There are relatively few studies concerning the development of the student teachers` beliefs and most of them focus on a comparison of student teachers` beliefs before and after special courses. Skamp and Mueller (2001) showed that student teachers in Primary school science have entry-level beliefs espousing teacher-dominated teaching and learning frameworks. Such students did not appear to change their opinions during their teacher education program. Hewson, Tabachnik, Zeichner, and Lemberger (1999) found that the development of student teachers` beliefs depends largely on coursework at the university, cooperative teachers, curricula, and the school environment. Veal and Hill (2004) evaluated one pre-service and one secondary chemistry teacher's beliefs during methodology courses, practical experience, and a student teaching internship. The study concluded that teachers` beliefs concerning content went unchanged, whereas those about teaching did evidence changes.

The purpose of this study is to provide a snap-shot of the beliefs prevalent among prospective chemistry teacher-trainees at different stages of their training program. Using a cross-level approach, this study researched three different groups: freshman student teachers of chemistry, student teachers halfway through their 5-year university teacher training program and a group of young chemistry teachers during compulsory in-service training after they finished their university program. All of the groups stemmed from the same educational and regional background. Our research questions were:

- *Which beliefs do chemistry student teachers hold about chemistry teaching and learning at the different stages of the chemistry teacher education program in Germany ((i) freshman chemistry student teachers, (ii) chemistry student teachers in the middle of their university teacher training program, (iii) young chemistry teachers in their compulsory in-service training after having finished the university program)?*
- *Are there any similarities and/or differences in the chemistry student teachers` beliefs about teaching and learning at the different stages of their chemistry teacher education program*?

SAMPLE

The sample consists of three different groups of prospective chemistry teachers from Northern Germany. The first group is composed of freshman chemistry student teachers (N=44). Data collection took place within the first two weeks of their university teacher education program, which was the start of higher education for to nearly all of the participants. Thus, these student teachers had not had any university courses prior to this study and had not been previously influenced by either university coursework or professors. The second group of student teachers (N=31) was halfway through their 5-year university education program (average 5th semester). This group had already had several chemistry lecturers and seminars, including some education and science education courses. The participants had just returned from a half-year teaching internship in school. The third group is made up of young chemistry teachers who had finished their university teacher training program and were taking part in an obligatory 18-month in-service teacher training period (N=20). These student teachers taught both chemistry and a second school subject for about 12 classroom periods a week, and additionally were required to complete 3-4 hours of pedagogy and chemistry education seminars each week as part of their teacher training. Some characteristics of the participants are presented in Table 1.

Characteristic	***Options***	***Freshmen (N)***	***5th semester (N)***	***End (N)***
Age	under 21	24	0	0
	21 – 25	11	23	0
	25 – 30	7	3	15
	over 30	2	5	5
Sex	Female	28	14	11
	Male	16	17	9
Federal State of Germany where secondary education completed	Bremen	6	8	11
	Lower Saxony	32	16	7
	North Rhineland – Westphalia	1	1	1
	Schleswig – Holstein	0	2	1
	Other	4	3	0
Type of school where secondary education completed	Grammar school	34	26	19
	Comprehensive school	6	4	0
	Other	4	1	1

Table 1: Selected characteristics of the participants in the study

The selection of this data sample is not representative in statistical terms. Nevertheless, most of these German student teachers have (i) similar formal qualifications for university access, (ii) comparable age and gender distributions and (iii) comparable university chemistry teacher education as on different German universities. Using this point-of-view as a springboard, there is no sound reason for us to assume that these chemistry student teachers are special in any respect. There can be no logical assumption that the results would differ notably by sampling a new test group from any other subset of German universities.

METHOD

In this study the participants were instructed to draw themselves as chemistry teachers in a typical classroom situation, and then answer four open-ended questions. This idea drew upon the 'Draw-A-Science-Teacher-Test Checklist' (DASTT-C) (Thomas, Pedersen & Finson, 2001) supplemented with further questions about teaching objectives, and prior activities (Markic et al., 2008). The data analysis pattern was developed using the beginning steps of Grounded Theory (GT) for generating categories out of the data (Markic et al., 2008). The range between the predominance of more traditional and more modern beliefs was selected as the core category based on GT. Three 5-step scales were developed, which focused on 1) *Beliefs about Classroom Organization*, 2) *Beliefs about Teaching Objectives* and 3) *Epistemological Beliefs*. Short descriptions of these three scales are presented in Table 2. The validity of the data was achieved through independent rating and searching for inter-subjective agreement (Swanborn, 1996).

	Traditional beliefs		*Modern beliefs*
Belief about Classroom Organization	Classroom activities are mostly teacher-centered, -directed, and -controlled and are dominated by the teacher.	↔ -2, -1, 0, 1, 2	Classes are dominated by student activity and students are (at least partially) able to choose and control their activities.
Belief about Teaching Objectives	The focus of chemistry teaching is more or less exclusively focused on content learning.	↔ -2, -1, 0, 1, 2	Learning of competencies, problem solving or thinking in relevant contexts are the main focus of teaching.
Epistemological Beliefs	Learning is passive, top-down directed and controlled by the dissemination of knowledge.	↔ -2, -1, 0, 1, 2	Learning is a constructivist, autonomous and self-directed activity.

Table 2: An overview of the scales from the qualitative part

RESULTS AND DISCUSSION

All three categories were interpreted as representing a spectrum between more traditional and more modern beliefs with regards to educational theory and research evidence (see Markic, 2008).

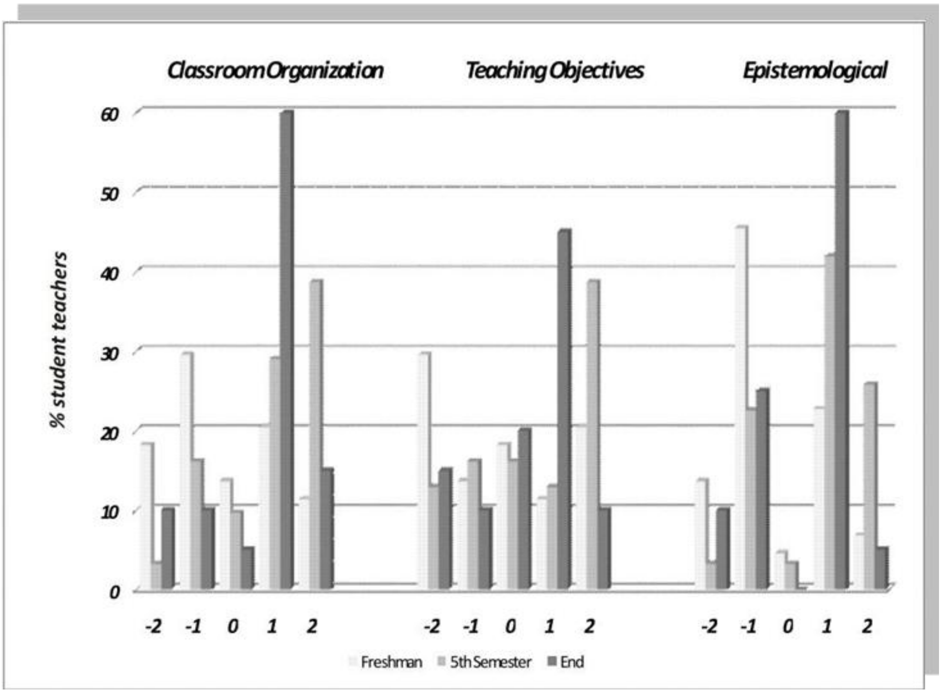

Figure 1: Visualization of the percentages for the three categories

The results in Figure 1 indicate a broad diversity of beliefs within the groups as a whole, but also show contrasts within the respective subgroups of chemistry student teachers. The 41 freshmen possess a wide range of beliefs about themselves as teachers and about chemistry teaching and learning. These student teachers evidenced a slightly more noticeable tendency towards traditional beliefs in all three categories as compared to the group as a whole. The 5th semester student teachers and those at the end of their university teacher training program tended to hold more modern beliefs when it comes to chemistry teaching and learning. The analysis of the 5th semester student teachers shows heterogeneous allocations for all three categories, but especially for *Beliefs about Teaching Objectives.* In the other two categories, this group leaned quite strongly towards student-centered and constructivist learning.

The group of student teachers at the end of their teacher education program expressed also more modern beliefs about teaching and learning. Their allocation of codes is noticeably more homogeneous. Concerning their *Beliefs about Classroom Organization* and *Epistemological Beliefs,* roughly 60% of this group emerges as being rather student-centered and quite constructivist when it comes to the question of learning. Although both the second and third groups profess more modern beliefs about teaching and learning in general, there is a difference between them. Whereas a large number of the student teachers halfway through their teacher training program had both strongly student-centered beliefs and strongly constructivist learning beliefs (both categories coded with a value of ‘2’), the student teachers at the end of their university training program hold to these beliefs less strongly (coded with values of ‘1’).

Another important aspect of the data is related to interpreting the data combinations found among the three categories. If a student teacher shows similar classifications in each of the three categories, then the combination of codes will appear along or near the diagonal line from (-2/-2/-2) to (2/2/2) in Figure 2.

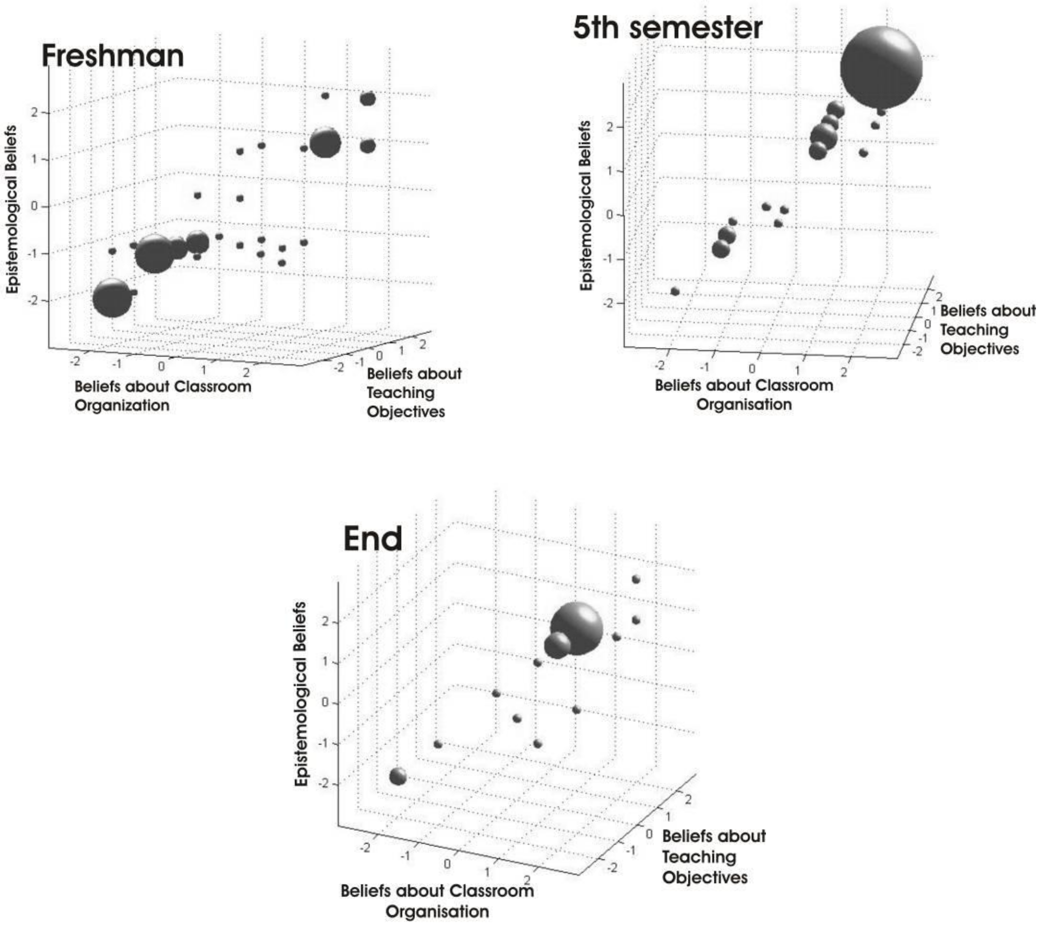

Figure 2: 3D-representation of the code combinations

Figure 2 shows a high proportion of student teachers’ code combinations occurring near the spatial diagonal. This means that the beliefs tested are interdependent upon one other (see also Markic & Eilks, 2008). Furthermore, the closer a student teacher’s code combination approaches the lower, left, frontmost portion of the three-dimensional plot, the more traditional the student teacher’s beliefs about teaching and learning will be. The nearer a code combination approaches the upper, right, hindmost corner of the diagram, the more the student teacher’s beliefs fall in line with modern educational theory.

Freshman student teachers of chemistry tend to bring more teacher-centered, content-structure and transmission-oriented beliefs about teaching and learning into their training. A majority of the collected data appears in the lower, left, frontal part of the diagram. Only a very few of these student teachers appear anywhere near the upper, right, back part of the diagram. Contrary to this result, most of the student teachers in the second group have results which are located in the upper, right, back part of the diagram. This indicates beliefs remaining more in line with modern educational theories. The data observed for the third group shows a similar pattern. This last group also favors by the majority student-centered approaches, including ideas stemming from constructivist learning, and an orientation towards scientific literacy objectives. In any case, these beliefs are not as strong pronounced as those held by student teachers in the middle of their university teacher education program.

DISCUSSION

The above results indicate that chemistry student teachers hold very heterogeneous beliefs about themselves as teachers and about teaching and learning when they are asked at different stages of their teacher education program. The data show that freshmen tend to hold quite traditional beliefs about chemistry teaching and learning (Markic & Eilks, 2008). Chemistry student teachers in the middle and those at the end of their university teacher training programs have more modern beliefs when it comes to teaching and learning, which are in line with modern theories of education.

As mentioned at the beginning, there is, of course, no absolute proof that the sample used in this study is representative for all German chemistry student teachers or beyond. However, this subset of student teachers is typical in the German context. Therefore - at least for the German situation - there are no plausible reasons for us to assume that the beliefs among other subsets of German students should differ radically. This is why we have carefully allowed interpretation of the data and discussed the implications which arise under such circumstances.

At the beginning of their university teacher training programs, the student teachers in this study appear to profess beliefs which may stem from their school experiences (see also Calderhead and Robson, 1991). From the start of their tertiary education, students decide exactly how their chosen career should be developed and carried out. Traditionally-held beliefs which depict teacher-centered classrooms, content-structure-oriented objectives and receptive learning do not seem to be a deterrent for students who wish to become chemistry teachers.

Certainly, the fact that this study showed that student teachers` beliefs about teaching and learning develop during their university teacher education programs is a step in the positive direction, especially since these views tend to evolve into more modern beliefs in line with actual educational evidence. It seems likely that university seminars and lecturers, who base their efforts on modern research theories and discuss theoretical aspects of their fields, can and do influence student teachers` belief structure in a more modern direction. Finally, it would appear that tertiary chemistry education has great potential in its continuous efforts to modify student teachers' beliefs about teaching and learning. Although this is good news, teacher education should also promote self-reflection in student teachers, so that they become conscious of their beliefs concerning their future profession (e.g. Schon, 1983).

This study also shows teacher beliefs not only develop from beginning to the middle, but also between the middle and end phases of teacher education, as was seen in this cross-level study. Generally, the beliefs of graduating teacher trainees tend to remain modern; however, they are not quite as modern as those measured in the group halfway through the educational process. The development here shows a retrogressive step and it seems that teaching practice can also influence teachers' beliefs in the other direction. The restrictions represented by everyday school practices, practitioners' colleagues in the school, and in-service training seminars also seem to have influence upon their beliefs. It seems to be a sound conclusion that exposure to the reality of the teaching career moves student teacher beliefs slightly back towards a more traditional style. The question remains as to how much or how little student orientation can or should be applied during teacher training. To prove this hypothesis, further studies are needed, wherein the beliefs of in-service teachers of different ages and levels of work experience can be compared.

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THE PROFILE OF FRESHMANS AT A TEACHER PREPARATORY COURSE IN CHEMISTRY, AND THEIR SCHOLAR TRAJECTORY

Luciana Massi

Instituto de Física/USP

lu_massi@yahoo.com.br

Alberto Villani

Instituto de Física/USP

avillani@if.usp.br

ABSTRACT

In this work we analyze the profile of freshmen students at a teacher preparatory course in Chemistry of a Sao Paulo public university and the school trajectory of nine, in order to examine the school route traveled by the students and the strategies employed by their families and themselves along the school route. The analysis of the profile was based on the student's answers to a written questionnaire and the analysis of their personal academic trajectory was based in semi structured interviews conducted by us. The research was supported by Bourdieu's studies, whose theoretical framework allowed us to identify, by their analysis categories *habitus*, cultural capital, social capital, economic capital and strategies, the objective mechanisms that influence the agents practice, behaviors, expectations and styles according to the school universe. The data showed the family participation in agents' school life, through guidelines, investments and examples, besides their influence in the agents routing to the higher education, that happened in a direct way.

Keywords: *school trajectory, chemistry student, education sociology.*

INTRODUCTION

Considering the limits and contributions of Pierre Bourdieu's Sociology of Education, this work is based on Bourdieu's reflections on the relationship between family inheritance (specially the cultural one) and school performance. The relation between school and family has been studied by many researches in the sociology of education area, some of this has been organized and published by Nogueira, Romanelli and Zago (2000).

Through this perspective, the object of this study was to analyze the profile and the trajectories of freshman students from a chemistry teacher preparatory course of a Sao Paulo public university.

For this purpose we considered some categories elaborated by Pierre Bourdieu, necessary for the understanding and uncovering the intricacies of the success or failure of pupils of different fractions of classes. They are: habitus, cultural capital, social capital, economic strategies. In addition to other information such as the level and the cultural environment of students, sibling number, birth order, gender and values that were also related to those categories.

THE THEORY OF PIERRE BOURDIEU

According to Pierre Bourdieu, the tendency of families to invest in the education of their children depends on the relative weight of cultural capital within the families' overall property and ethos. In this context, ethos refers to children's educational future, seen as what is possible for them. In other words, ethos has to do with the objectively determined likelihood of academic success, and it varies in function with the conditions of existence of each group of agents. Groups absorb these possibilities and express them subjectively in the form of desires, prospects, length of formal education, professional choices, and attitudes toward school (BOURDIEU, 1989).

Each family transmits a cultural inheritance to its descendants. This inheritance, which is purely social, consists of the unit's cultural capital and ethos, and it differs from one social class, and sub-class, to another, according to their social milieux. This inheritance can be understood as a set of types of knowledge, awareness, attitudes, interests, aims, information and linguistic codes. On the one hand, ethos, which is the result of a process of appropriation of the likelihood of success in school, defines the relationship of the social agents with cultural capital and with the school. On the other hand, cultural capital directly influences children's success in school. In Bourdieu's conception, inequalities in performance among agents in the educational system are due to the fact that schools, either consciously or unconsciously, demand of all their agents familiarity with the culture and language in order for students to progress without failures or interruptions. To summarize, they demand that agents have prior knowledge of the codes needed to apprehend the dominant culture that the schools are geared to transmit. For them, agents must have a natural and familiar relationship with culture and language, which gives greater emphasis to their relationship with knowledge, than to knowledge itself. This relationship of intimacy with culture and language, which includes verbal proficiency and cultural competence, is related to their modes of learning.

In Bourdieu's conception, this familiarity with culture and language can only be appropriated by the agents in the context of the family environment, through imperceptible learning provided by the families, which are bearers of the culture of the dominant class. He adds that, since this familiarity with the culture is provided through imperceptible learning in the family context, with no methodical effort, the agents are not aware of it and, as a consequence, this knowledge is attributed to individual talent, vocation and innate aptitudes.

In his view, dominant classes and class fractions have the power to impose on schools criteria for evaluation that correspond to their own educational expectations and cultural products (1974). Schools, therefore, through the verdicts (judgments, sanctions, demands, warnings, advice, etc.) of these sectors of society, implicitly value this dominant culture (especially through verbal proficiency and familiarity with knowledge) and demand it from the various agents, which have acquired different cultural inheritances. The farther this inheritance received from the family diverges from the dominant culture, the less "value" it receives in the eyes of the school.

Bourdieu (1989, 1998) also emphasizes that information about the functioning of the educational system and educational institutions, as well as about the professions of broadest social prestige and the paths that lead to them, make up one of the most important and profitable components of cultural capital that fractions of the cultivated class make use of. He also stresses that to obtain, this familiarity with the culture and language through subtle and imperceptible learning often unconsciously imparted by families, cultural practices must occur in the family context. Families must have the will, or the inclination, to consume the cultural goods considered legitimate. They must therefore encourage their descendants to also take on these practices. Cultural property considered legitimate includes "the symbolic property that a social formation chooses as worthy of being held and desired" and represented by means such as books, periodicals, and frequency at theaters and museums, cinema, and so forth.

From Bordieu's perspective there is an intimate link between a family's educational level and its interest in consuming symbolic goods, since, to consume an item of symbolic value (reading, music, etc.), the agent or group of agents must have acquired the instruments of appropriation and they must internalize the codes needed for deciphering them. He also stresses that, to frequent concerts and movies, families must also have accumulated the corresponding economic capital. He also underscores that a family's educational level also determines the importance it gives to such cultural practices, such as intellectual discussions and the age at which their offspring begin to consume such symbolic goods.

From this perspective, it can be said that the history of these agents (their successes, failures, choices of educational institutions, and professional choices) are related, on the one hand, to the cultural capital inherited from the family and, on the other, to the ethos, among other aspects, and to the family's inclination to invest in its children's studies. According to Bourdieu, this cultural inheritance comes from the *habitus*, which is one of his most important concepts. In his view, habitus presupposes past learning, which is at the basis of the structuring of all later learning. It can be defined as:

"systems of durable patterns, structured structures, that are able to function as structuring structures. They act as a generating and structuring principle of the practices and representations, and such representations can be objectively 'regulated' and 'regular.' But they are not the product of obedience to rules that are objectively adapted to their purpose. Nonetheless, one need not suppose any conscious intention of the ends and expressed mastery of the operations needed to attain them. They are collectively orchestrated without being the product of the organizing action of a conductor (BOURDIEU, 1983, p. 60-61).

According to Bourdieu, the material conditions of existence proper to a particular type of milieu, namely, a milieu which is proper to a given social group or class fraction, and their concrete function in the family context, constitute a fundamental type of mediation in the production of the structures of the habitus.

From his point of view, the identity of material conditions of existence that characterize a given group or class fraction tends to produce similar systems of disposition, at least partially, in all the agents that share these same objective structures, and this results in the relative homogeneousness of the habitus. In other words, agents of the same class fraction submitted to the same conditioning and that are therefore placed in an identical objective position, pass through a process of uniformizing the habitus. They are thus distinct from agents that belong to other social groups. According to Bourdieu, this relative homogeneousness of the habitus is at the basis of the objective harmonization of the practices of all the members. They belong to a given social group, a factor that provides them with a regularity and an objectivity that align their actions without appealing to explicit norms or rules established by the social group or class fraction. In this sense, the habitus serves as the unifying principle of the actions, or practices, of the agents involved.

As Bourdieu (1983) explains, the habitus is the universalizing mediation that makes practices be seen as "sensible," "reasonable" and objectively orchestrated without there being explicit reasons for this and without a significant intention of a singular agent. From this perspective, it can be said that an agent's past persists in the present. The habitus deposited in each agent, within family relationships, brings about analogical transfers of schemes and matrices of perceptions and apprehension. They are at the origin and precede an agent's practice when he or she faces a given situation, thus assuring the presence of past experiences, that are restructured in the here-and-now.

In Bourdieu's conception, the habitus is a system of dispositions "strongly reinforced with regulated improvisations." In other words, the habitus, understood as "analogical transfers of schemes," lets agents behave in very different ways toward new experiences. But this behavior does not arise as unpredictable or unforeseen because the habitus acquired in past experiences is always the basic principle and support. Therefore, such behavior, as a tendency, is recognizable and predictable by all the agents that have acquired the same habitus under the same conditions.

From what was discussed above it can be said that the habitus is "a system of dispositions" acquired in a given family milieu and under certain objective conditions. Its product is not only the cultural capital of the family and its progenitors, but also its actions and practices, consciously or unconsciously organized in common to function as strategies of reproduction. At their final level, such strategies are aimed at maintaining or improving the position of a given social group in the structure of classes. Since the strategies have the habitus as their unifying principle, they are objectively harmonized to serve that purpose.

At this point, the importance of the relative value of the cultural capital of specific families might be brought in as examples. These families are necessarily part of a given class fraction and their importance is related to the structure and volume of their goods.

Bourdieu (1974) cites cases where the educational system is seen as the only means for social ascension. Specifically, he is referring to children of the teaching fraction of the middle class and, especially, young people from the working and middle classes who readily adhere to the importance of education. They expect everything from the school and depend on it, often making up for the privation of cultural capital by developing an intense desire to acquire culture. The results presented by Nogueira, Romanelli and Zago (2000) that analyzed scholar trajectories from popular and medium classes confirm these cases.

METHODOLOGY

The academic histories of students in the undergraduate area of the Institute of Chemistry were studied through semi-structured interviews. To define those students to be interviewed, we made contact with classes in the first year of the teacher-training course (licentiate)[16] in chemistry. The first contact was with a teacher responsible for one of the subjects studied by the group and, after obtaining authorization from the teacher, we contacted the students themselves. At the first meeting we introduced ourselves and briefly described our research project. We then asked the students to fill out a short anonymous socio-economic questionnaire. The last item on the questionnaire asked the name and basic information (email and phone number) for contacting the students who were interested in taking part in interviews about their academic histories. We then collected the questionnaires, classified the students to be interviewed and scheduled sessions with them. At the beginning of the interviews the students were informed as to the topics to be discussed and were asked to fill out a declaration of informed consent. The interviews were conducted according to a semi-structured model, where we defined topics the students had written about on the questionnaires. Further questions were then asked in order to complement the information they had already provided. As was expected, the students added further topics and provided facts about their lives which we had not specifically requested.

16 The technical term “licentiate” (*licenciatura* in Portuguese) is used here as synonymous with "teacher-training course." It confers a degree which gives graduates the legal right to teach the subject or subjects (major or minor) they have studied in university. In contrast, the bachelor's degree is geared to preparation to practice the corresponding profession.

The topics and sub-topics defined for the interviews were: 1) family: the students were asked to describe their level of education and the economic and social situation of their parents, siblings, uncles, aunts, cousins and grandparents; 2) school life (elementary and high school): they were asked about the ages at which they studied in the different grades, the type of school, and the relationships they developed with their teachers and classmates (this point included their academic attainments and to what degree their families had participated in their school life; 3) higher learning: in this item the students stated whether they had had to take crash courses after high school to better prepare for university entrance exams, at what age they began university, how they chose their undergraduate courses, how their families saw these choices, and how they are performing academically in university now; 4) cultural practices: the students were also asked about their facility with foreign languages, their reading habits, whether they played any musical instrument, whether they played any sports, whether they traveled or went to clubs, bookstores, libraries, museums, shows, etc.

STUDENTS’ PROFILE

As we discussed, in order to analyse and determine the student’s profile short questionnaires were distributed in class for freshmen students from a chemistry teacher preparatory course to which all present students responded in writing and anonymously. Questions were the following: What is your gender? And your date of birth? What is the district / city where you live? What's your dad’s profession? What is the profession of your mother? What is your income? In which fraction of class would you situate your family? What is the level of instruction of your father? And your mother? Do you work? What did you do? Do you have a scholarship?

The analysis of the questionnaires distributed to all students of the course allowed us to determine a general profile of the class. There were 35 students that answered the questionnaire. We realized that the majority of students were female (77%), and their average age is 19,8 years old, considering that it varies from 17 to 23 years old. The chemistry teacher preparatory course is offered in an inland city in the state of Sao Paulo, so a greater part of the students (43%) came from other cities, most of which are in the Sao Paulo’s inland, and now live in the city where the course is offered. Another part of the students live with the family in the city of the course (37%) and some in surrounding cities (20%). The family monthly income of students varies from 300 to 4500 USD, but most lie in the range from 1200 to 1500 USD and considered themselves as part of the middle class. The educational level of their fathers and mothers were in most part high school education and higher education. The father’s professions were in most part bank managers, salesman, managers, freelancers, entrepreneurs, among others. And most of the mothers were housewives, teachers, seamstresses, secretaries, and others. From the total number of students that responded, only 6 (17%) work and 18 (51,4%) have a scholarship.

Fiamengue (2002) has also analyzed the profile from the students of the same public university, including the chemistry students, and their results are consistent with the data we’re presenting in this work.

STUDENTS' ACADEMIC HISTORIES

Among the 35 students analyzed in this study, semi-structured interviews were conducted with nine of them (five females). After transcription of these interviews we’ve done a preliminary and qualitative analysis of the data, so certain elements common to the personal academic histories of many of the students could be seen. We considered not only the frequency of these elements or themes, but also its occurrence in the same interview. Our concern wasn’t just to characterize that population of students, which we have already done by the questionnaires analyses presented above. After the determination of these themes we also decided by their relevance according to Bourdieu's theory, then we returned to the interviews and analyze it again. In this text we present these elements and briefly discussed them below. In terms of the period before entering university, we emphasize the following aspects, which will be discussed below: efforts exerted and investment in studies; follow-up on school life by the family; the school aimed at a better future; examples of academic success among older family members; "financial sponsors" in the family; and the role of religion, athletics and music.

The students' accounts of life at school indicated how much effort they had exerted in their courses, especially as they neared the time to face university entrance examinations. They also described the financial investment their families had made in their education. Most of the students (six of the nine) had attended private schools, at least during the final years of high school, as such institutions are considered better than public schools. Besides these direct investments, other strategies were also mentioned that indicated the importance families gave to studies. One example was the case of the Student I (female) whose mother had given her a small sum of money for every book she read, in order to encourage the girl to develop a taste for reading. Another example:

"My father never made us work. He paid tuition at private schools, today I can see this, so I think that the very least I could have done was to get into university right after graduating from high school. [...] But at the time the only thing I was really interested in was dating, and I wanted to study at [a local university] because it was near home. I remember my father wouldn't let me go there. He said 'No. I'll pay for one year of a preparatory course for entrance exams so you can get into a better university, but no more going out during the week. You're going to study and on the weekends you can go out. But I want to see you study because I paid for a private school and even so you didn't get into university. So you have one more year.' And I realized I had better make the best of it." (Student C - female)

We also noted that all families exercised some degree of monitoring of the student's academic lives, either by merely going to parents' meetings and checking report cards or, more closely, such as by checking notebooks and homework, giving "quickie oral tests" at home, and giving dictation, these practices were more common in the first years of education.

"My mother would correct my homework, erase things and tear out pages in my notebooks that were wrong. [...] She would check everything. She worked during the day but at night she kept after me. [...] She always wanted to see my notebook. The worst thing was when I had to show her my notebook because she would tear out whatever was wrong and make me do it again. I would cry and I had to do it all over. Wow! [...] I didn't like it. [...] My parents always went to meetings at school. [...] I was never a top student. I was always average. [...] My mother [...] would swear at me and say, 'You never study! You're an idiot.' You know, that kind of mother, and they leave scars. I still remember all that. Wow! She would fight with me all the time." (Student E - female)

In other words, the families were concerned with school work, an attitude that is reflected in these practices and in the discourse about the importance of a university education in order for the students to have a "better future." For most of them this discourse seemed to have a greater effect when it was accompanied by positive examples, such as there being at least one family member who had finished university and who had thus shown the student a possible path in life that included interesting prospects. In seven families only older siblings, cousins or uncles and aunts had gone to university, but these examples proved to be significant for the students. In the other two cases almost all the members of the family had gone to university and the students faced that possibility as something natural.

"I think I'll make it OK. A lot of people have changed their opinions about me. That's what's good about studying, about achieving, overcoming obstacles. [...] You don't have to prove anything to other people, but you do end up showing them you can do it. Every day my brother [who has a teaching degree in chemistry] moves ahead a little bit at the factory, and there are people who just

want to step on him. I can see that. He tells me about it and it's cool if you can prove your ability and show that you're competent and that you have succeeded. Today I see that if you study you'll get ahead. Nothing's impossible. I never imagined I'd be studying here at Unesp or any other university and here I am. And I got accepted into São Carlos and Fatec, too. I think that if you really study, you can get ahead." (Student D - male)

Concern with schooling can also be seen beyond the nuclear family. Two students told about uncles, aunts and grandparents who paid the tuition for their courses or private schools, which we consider a type of "financial sponsorship."

One of the aspects that came up in four different interviews was the student's connection with the Catholic Church, either through regular attendance and participation in religious groups or through the option of the students to study at Catholic schools. This contact stood out because it apparently brought about a closer relationship with the surrounding culture.

"Yeah. I participate in a youth group. I'm one of the coordinators and so, apart from my classes and course, this is my main interest. [...] So I always have something to do. [...] Since the beginning of 2005 [...] I've taken part in the group and this has helped me be a person, how to be a person. I learned about the paths you shouldn't take and the paths you should take, so I'm sure that this has been an enormous help to me." (Student H - male)

We also saw how often sports were mentioned in the interviews (four of the nine). The practice of sports is encouraged by parents, not as an occupation but as an activity that provides students with discipline, health and responsibility and often improves their performance at school.

"I started playing basketball in the seventh grade. [...] It took up a lot of time and [...] sometimes I'd get up at five in the morning and get home at ten at night. So I spent a lot of time away from home. [...] I kept this up until I was a sophomore in high school and I was used to a long day of activities. [...] Even today I tell my mother that basketball gave me discipline [...] because now I can spend long periods of time at things because there were schedules I had to obey. So I think that's how it gave me a lot of discipline. [...] Today I can sit down and study for hours on end." (Student F - female)

Several aspects concerning entrance to the university and the first year of study will be discussed here. The most important are the following: information about the educational system, difficulties to overcome in entering the various courses, general and specific problems in staying in the course, and compensations, opportunities and recognition of the institution.

Most of the students interviewed (six of the nine) were considered good or excellent students during elementary and high school, but some had to struggle to get into a public university. This meant that almost all of them (eight students) found it necessary to take a course to prepare them for the university entrance exams, sometimes for over a year. From the students' accounts we gleaned the impression that one outstanding feature of admission to university was not the amount of time the students dedicated to their studies or the type of course they took, but rather the information they had about the educational system itself. For example, students who were already aware of the profile of the course and entrance examination for the Institute of Chemistry knew that the area for teacher training (licentiate) had fewer candidates than the bachelor's course. It therefore gave them better chances of entering, even though the two courses eventually conferred the same professional rights as defined by the State Chemistry Board. Five students took the test for the bachelor's course and failed after a whole year of preparation. But in the meantime they had discovered about the differences and equivalence between a teacher-training degree and a bachelor's degree, and were able to be admitted to the teacher-training option. The other two took the exam for teacher training the first time around, and were accepted.

"In my senior year I found out that the educational philosophy of the people giving preparation courses for entrance exams was different and that it would be better to take the course I was really interested in, which was chemistry. I took the exam for chemistry at all the universities that have this course [...] and I took the exam for teacher training in chemistry here, too. [...] Actually, the area I'm most interested in is biochemistry, but there is no such course in Brazil. [...] I also knew that teacher training was geared more to giving classes, while the bachelor's course was more for industrial and research positions. But the course here has prestige and I said to myself, 'I'm going to get a teaching degree there since there is less competition.' So I opted for the course here because I knew it would give me the same professional qualifications as a bachelor's degree. So it's a teacher-training course that is not focused just on education." (Student G - male)

In this same aspect the researchers noted another factor during four interviews, namely, that the course in chemistry, especially the teacher-training course, was not always the students' first option. Some would have preferred more competitive courses such as engineering or pharmacy, and some wanted to take courses their families did not approve of, such as music or art, because of their limited professional perspectives.

"At first I wanted take dancing, but I got no backing at all, from anybody. My mother kept saying that there wasn't much future in dancing, especially here in Brazil, a country that doesn't give much value to the fine arts. [...] She was thinking about what I would do after I graduated, you know, [...] like open a dancing school and have to get by on fees paid by students. It's not easy. She kept saying 'forget it' and I kept on trying, but I finally gave up." (Student A - female)

In spite of this, we could perceive that very few students think about giving up on their chemistry course. They basically say, "I'm not going to give up after all the trouble I had to get in." In this regard, they try to "compensate" at the Institute of Chemistry itself. For example, some of those who wanted to study pharmacy took training programs in the area of biochemistry; some who would have preferred engineering made contact with teachers involved in technological projects; and others yet, who were more interested in the arts, are involved in drama activities and other such options.

"I have a PAE-1-type scholarship [...] so my project is to write a report at the senior high school level so I can learn how to write reports. I could choose any topic I wanted in the area of biotechnology, so I decided to write something about energy production based on biomass and now I'm working on it, you know? [...] It's interesting because for a while I wanted to take aeronautic engineering but [my scholarship advisor] didn't even know about my interest in engineering. He said there were lots of possibilities in the area of chemistry, even if I took the teacher-training course. [...] A secretary here at the institute said there are lots of job opportunities. I told her I wanted to study space sciences [...] and she said 'Oh, wow, who's to say that there are no chemists at Nasa?' And there are! So I thought 'that's cool, isn't it? It's a possibility.'" (Student F - female)

The search for training programs in "Introduction to Science," or for extension projects, is not always directly related to the attempt to "compensate." It often has to do with the idea that the student should "make the best of every opportunity" the institution offers.

"When I first started here I met a guy older than me [who helped me out]. [...] When I chose chemistry I already knew all about [the courses]. I knew that a teacher-training degree from UNESP carries weight and I knew you could take different courses and get both [teaching degree and a bachelor's degree]. [...] When I came to register I met this guy [...] and he told me about the Science Center. He asked me if I wanted to go over there. They have monitors, a physics lab and a chemistry lab □ ' But I said I didn't have enough schooling for that and he said, 'don't worry; they give you the training you need.' So I took an entrance test and passed it, and even got a grant, [...] (because I needed some sort of help just to get by). I knew they gave out grants at the University in Campinas (UNICAMP) but I didn't know they gave them here, too. [...] I wanted to teach and after I started

studying at the Science Center I wanted to teach even more. So I said to myself, 'This is exactly what I want.' I had thought about transferring to Unicamp, but I decided to stay here."' (Student B - male)

We feel that this also reflects the value that students give to studying, to the Institute of Chemistry and to UNESP. During the interviews all students indicated that they feel proud of being part of such a well-known institution. But something else seems to tie the teacher-training students to the institution. They consider the school an extension of their own families. The students interviewed seem to associate the opportunities the institution offers, and the encouragement they receive from their teachers and advisers, to the stimulus they received earlier from their families. This can be seen in one specific detail. All complained about numerous subjects in the undergraduate courses they took. For example, they complained that the courses were too theoretical and showed very little or no practical applications, or they mentioned great difficulties in subjects such as calculus and physics, since they were not familiar with the specific codes of these areas. But the complaints were presented as inevitable or temporary and the students feel they will be forgotten as soon as they are overcome, somewhat like the way people forget about the differences and adversities that families go through.

"Adaptation was a little difficult. [...] Academic work goes at a different pace. It's not the same as at a preparation course for entrance exams. That kind of course is easy. [...] But not here. Here it's one book a semester. In calculus, for example, [...] I thought it would be easy. [...] I had no idea it was so hard. You know. Like having to be poring over books until 2 a.m. and then having to get up at 6:00 to sit down and study some more. I can't do that yet, study for ten hours straight, but I can go eight. At least now I can. [...] I don't get as distracted as I used to. [...] It'll take some time. This first year was a period of adaptation and that's why I don't worry too much about [having failed in several subjects and having to repeat the year]. Did I study? Yes! Did I study enough? No, I didn't! I didn't know enough. I have a problem of not having a good basis [from primary and high school]. [...] I want to teach, I really do, but I have to know what I'm talking about and I can't be bounced ahead in school. Anyway, they don't do that here. If you get a 1, it's a 1, so I don't mind doing the year again. Some people get desperate. So I have to take Calculus 1 twice? Yes, I have to do it twice, but I'm going to learn Calculus 1. I already learned something, but not enough, you know." (Student B - male)

"It was really hard. The first week I liked everybody [...] and my parents did too. I got to know the whole school and [...] I liked the people there. They were all so welcoming. [...] The students, everybody was nice. [...] Then classes started and I started to have trouble. Calculus was especially hard.[...] I failed in one subject and I'm taking the make-up tests now. [...] I'm doing badly in Calculus 2, too, [...] since it's new for me and I have to learn a lot in a short period of time. It's really hard. I don't know. I don't feel like sitting down and studying. [...] I don't know if it's because of the course [...]. I don't give up easily. I think I'll just keep going as far as I can. [...] There's nothing else I'd like to do. [...] If I go on to another course, my family will, you know. [...] It's really the family factor. [...] I like chemistry. In fact, I love chemistry. The first year is hard in any case, right? You have to adapt. [...] That's everything! It's a different pace of study. Everything is different. [...] There aren't many practical classes; everything is classwork, so I'm hoping. Everybody says the first year is the hardest." (Student A - female)

CONCLUSIONS

Our analysis would seem to show this relationship between the wealth of agents and their school history, as was the objective of this study. We have tried to highlight certain features in the students' accounts during their interviews. We noted, for example, that it is part of the *habitus* of these families to participate, at home, in the students' academic life by motivating them to study and, in general, to attain some success at school. In terms of school and studies, another strategy used by this *class fraction* is to have sent their children to private high schools whenever possible. On the symbolic level, we note that families in this social category see the university as having the role of training the agents professionally, since a university degree is virtually seen as a "regular part of life." It is seen as a way (a maintenance strategy) for this social stratum to continue in the social structure. It's important to analyze these facts through the *habitus* concept which links the social and the individual context. So, we considered that these students were surrounded by a social and familiar mileux that valorizes the studies and the university, for the reasons we have already discussed, but for some psychological and individual reason, that were not discussed in this work, these values were absorbed by the students and constitutes their *habitus*, as we can see through their statements.

In general, we observed that it seems that the students from this course presents three main characteristics in their way to became a graduate student at a teacher preparatory course in chemistry from this specific public university: they face a long preparation time before entering the course; they give up on their initial professional dreams; and they are supported by their families during all this process.

We believe that although their families considered that the university was an obligatory step in their preparation for professional life, they didn't know the "codes" that rule this educational field. It sometimes leads to a longer preparation time before entering the university, that was reduced in some cases by the social capital that the students had. Even without this knowledge the families were always supporting the student's path, which help them to achieve their goals. The data showed that the families participate in the agents' academic life by setting up guidelines, investing and giving good example, besides their earlier and direct influence in routing the agents toward higher education. But, this lack of knowledge about the higher education that the students and their families presents also led them to "impossible" dreams, like being musicians or engineer without the appropriate preparation to these professions. Or even led them to choose bachelor's course, that gave less chances of entering then the teacher training course, even though the two courses eventually conferred the same professional rights as defined by the State Chemistry Board. Then, some students took the test for the bachelor's course and failed after a whole year of preparation. After failing, these students chose a profession and a course adapted to their medium knowledge obtained by a huge effort, this kind of choice regulated by the social milieu has been described by Bourdieu as the "causality of the probable".

We also realize that many students presents difficulties to accompany the course. We believe that some of these difficulties might be related to the long preparation time they took before entering, which means that maybe these students entered even without having the minimum knowledge demanded by the course, or that the course is not adapted to the characteristics of the students that entered – and so it had to support the students, continuing that preparation time they had before entering the university.

Another characteristic that stands out is the students' determination to continue on in their course despite these difficulties they encounter along the way. Certainly one important contribution to this determination is related to their personal and family efforts and investments made in preparation for and entrance into the university. The prestige of the institution is also part of this effort, but we believe that the opportunity to compensate for problems that come up and the interest of the university teachers toward the students also contributes to support them in the choices they have made.

In our opinion, the information obtained in this study is significant and we feel it can be used by the institution itself in its plans to monitor students with different types of cultural capital, backgrounds and profiles. This type of activity on the part of the university would be aimed at keeping the students in university and at restructuring their *habitus*. We perceive the institution's success in providing the students with different activities and we feel that these actions should be maintained and even expanded.

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A TAXONOMY OF INQUIRY ACTIVITIES

Daniel Z. Meyer

Illinois Institute of Technology

meyerd@iit.edu

ABSTRACT

Inquiry has become the central focus of science education. Much of the work looking at the specific structure of inquiry activities has either been general goals or rubrics for assessing the degree of inquiry learning. This paper is intended to illuminate the means for achieving those goals and levels by articulating a taxonomy of different structures for inquiry activities.

Keywords: *inquiry, curriculum.*

INTRODUCTION

Inquiry has become the central focus of science education, and prompted several veins of scholarly work to support this effort. However, we are concerned that there is a gap. Work looking into the structural details of inquiry have occupied the ends of a spectrum from general to specific. On one end, we have articulations of goals or rubrics for assessing existing activities (Breerer & Bodzin, 2003; Herron, 1971; Wheeler, 2000). On the other end, we have specific activities or rich descriptions of inquiry in practice (Minstrell & van Zee, 2000; National Research Council, 2000).

This paper is part of an effort to fill in the research base. By identifying structures for inquiry that are more general than individual activities, but define means to achieving the standard characterizations of inquiry, we provide guidance to teachers and other instructional planners. Here, we share a categorization of inquiry activities.

NEEDS OF INQUIRY

The inquiry addendum to the American National Science Education Standards (National Research Council, 2000) identifies the following as the essential features of classroom inquiry: 1) Learner engages in scientifically oriented questions; 2) Learner gives priority to evidence in responding to questions; 3) Learner formulates explanations from evidence; 4) Learner connects explanation to scientific knowledge; 5) Learner communicates and justifies explanations.

This defines a good target, but we wish to address the problem of how to create the conditions in the classroom where these learner activities can happen. We have identified two specific hurdles that must be overcome (Author, in review). First, asking and appreciating scientific questions requires working from some base context. While attention to the prior knowledge of students is certainly critical to any teaching, engaging in inquiry requires a meaningful reference point for participants. Therefore there is the Getting-on-Board Problem of how to orient students to a particular scientific context. This is a problem that is overcome in the world of practicing scientists through participation by new practitioners in the research programs of more senior practitioners. But in precollege and even college academic settings, this cross generational engagement is extremely difficult and rare. Second, formulating, communicating and justifying explanations requires that those explanations not be trivial. There must be something to have contention over. Therefore, there is a Variability Problem of insuring some degree of complexity in the data students will work with. Whereas, the work of practicing scientists is by definition in the areas of dispute, the focus of precollege science education is generally over very well established content. Overcoming the Variability Problem is not a matter of simply shifting topic area, however. There are often technical and cognitive barriers to facilitating student access to those areas that have more potential for contention.

Two key decisions for the designers of inquiry activities are the choice of task to give students and the choice of data with which they will work. Each choice is a balancing act. If a task is too prescribed, the activity becomes a cookbook lab. If the task is too open, students may not be able to even begin. If the data set is to simple, the activity becomes a confirmation lab, with nothing to contest. If the data set is two complex, it may be beyond students technical or conceptual abilities to work with.

TAXONOMY

To date we have identified six categories of inquiry activities. Each provides a different structure for overcoming the two problems in designing inquiry activities described above. The first three we refer to as heuristic categories because their structure not only describes their nature but also provides guidance for forming original activities. The other three depend more on the intrinsic appeal of the situation they create. The first two come out of specific past curriculum development projects. The remaining categories have been formed by considering other inquiry activities that do not correlate to the original two categories.

PROTOCOLS

A *protocol* is a well-defined procedure for collecting data. In terms of definition and clarity of steps, it is quite similar to a traditional cookbook lab. However, it is portrayed as being clearly just a tool – as opposed to the entirety of the lab experience. More importantly, a protocol can be applied to a wide variety of situations – not just the situation in which it is introduced and learned. (Hence some cookbook labs can be adapted to form protocols, but others cannot.) Once the student learns the protocol in an initial circumstance, they can then apply it to further research. This research can be more varied and more student directed.

The prototypical case of a protocol is the lettuce seed bioassay (Trautmann, 2001). Students are given fairly clear directions for producing a serial dilution of a salt solution, setting up a bioassay using lettuce seeds, and evaluating the results. Once they have had that experience, they can now engage in further, more varied research: other concentration ranges, other toxins, and even other biological indicators. At the most sophisticated end of the spectrum, the bioassay can become a moderate piece in a larger extensive research endeavor.

Another example of a protocol is the Watershed Habitat Evaluation and Biotic Integrity Protocol (WHEBIP) (Carlsen & Trautmann, 2004). This protocol was created to allow scientists to use models to predict aquatic biodiversity in watersheds. In this protocol, stream integrity ratings are assigned using land use criteria and can be accomplished using aerial photographs or remote sensing without requiring ground truthing (although in some instances, it is appropriate). Ratings are based on information students assess including size of riparian belt, type of land use near stream, gradient, pollution, and conservation activity. Students can use this protocol to make a preliminary assessment of a habitat and if desirable, make comparisons to data gleaned from ground truthing. This tool enables students to obtain data for one or multiple sites within watersheds or comparative studies between watersheds, and to make recommendations for remediation.

Learning a protocol is not just a question of now having a new technical skill. It overcomes the Getting-on-Board problem by introducing student to an entire way of looking at the natural world. The data set they produce in the initial learning round is also significant. It can be an indicator for what merits investigation next, just as with science at large. Hence the student has been brought on board the knowledge development cycle.

DESIGN CHALLENGES

Design Challenges are centered around an explicit production task. Often the task will motivate the practical need to acquire certain knowledge bases. Sometimes inquiry designers will use a jigsaw arrangement, where students are divided into specialty groups to learn one of those knowledge bases, then rearranged into design teams made up of representatives of each specialty group.

Forming the charge to the students is the critical and creative focal point of designing Design Challenges. Doing this well can determine if the balancing acts have been achieved. A way of framing the problem is to give students a question that is understood as a question, but not as a solution. A question for which students already have a single, preconceived solution will not generate the argument opportunity necessary for inquiry. At the other end of the spectrum, a task for which students have no conception or ability to proceed is equally unfruitful. But it should also be noted that there is another way in which Design Challenges can be too open-ended. Consider the challenge for middle school students "design and build a paper airplane." This avoids both of the problems noted so far: students understand what a paper airplane is and have the intellectual and material resources to do so; and they are likely to propose multiple solutions. But then what? The litmus test we put out above requires *warrant*-based arguments – essentially saying "this is better because of such and such". As stated, this design challenge does not include any means to defend why one design is better than another. The challenge is *too* open – not in term of students' cognitive or technical ability to achieve it, but in terms of it being a meaningful competition. Design Challenges must include pressures that require student designers to make judgments and back up those judgments with arguments.

While producing a tangible object is perhaps the more common instance of design challenges, we should not limit our view in this manner. The common element is producing a product. Consider the following example (Author, 2003). Students are given a scenario of a local community that is experiencing pollution in a local waterway. The students are divided into different constituency groups: farmers, homeowners, industry and municipal authorities. They are given a variety of information resources – some common and some specific. They then have a variety of meetings – some in homogenous groups and some in heterogeneous groups. The task and final outcome of those meetings is to develop a restoration plan.

Design challenges can also result in tangible products. One example of this is the stormwater treatment design challenge (Carlsen & Trautmann, 2004). This activity models how cities develop systems for collecting and draining runoff from storms. Using simple materials such as plastic soda bottles, tape, coffee filters, cat litter, sand, gravel, and plastic tubing, students are given the task of creating a filtering system that can handle a simulated storm event over a relative period of time. They need to take into account the various types of substances (such as chemicals, dirt, oils, etc) found in runoff, the volume of the storm event, the time between events and the extent to which the stormwater needs to be filtered. Like engineers in the real world, they are also constrained by materials, guidelines, budget, time and design. From a curriculum design point of view, the specifics of the design constraints (size, materials, etc.), evaluation measures (ph, DO, etc.) and simulated run off (particulate matter, oil, etc) will be what determine how the balancing acts have been achieved.

Just making something, however, does not make an effective design challenge. It can just be the Design Challenge equivalent of a cookbook lab. Consider the common example of students in physics classes designing roller coaster rides. The details of the assignment are crucial in determining whether this is an effective Design Challenge. Often, students design the ride in a fairly arbitrary way, and then post facto apply physics principles to determine elements like speed. The laws of physics do provide limitations on the design (e.g. a hill can not be too high that a car will not have the energy to reach the top). But there are not competing constraints that provide for points of debate. Once a student stays within the bounds of physics, any choice is an arbitrary preference, and hence, there is no opportunity for argumentation.[17] This illustrates how the details of an assignment can have a profound effect.

PRODUCT TESTING

Product Testing activities present students with a question of the form “which is the best X”. This requires students to devise and implement ways to consistently compare items, and often to quantify those comparisons. This means recreating a phenomena in a controlled, reproducible and measurable manner.

This challenge often breaks down into three parts. First, students must determine what the desired attributes of the product are. Second, students must devise ways of consistently testing those attributes. Lastly, they must determine a way of combining the results.

A simple example of a Product Testing would be determining the best paper towel. Students would first have to design what attributes effect the desirability of a towel. This might include absorption, strength and price. Then they need to devise ways to test and quantify those attributes. And lastly, given the results of that testing, they must integrate the results to choose a best paper towel. Product Testing therefore overcomes the Variability Problem with three separate opportunities for contention.

Overcoming the Getting-on-Board Problem is often helped through the use of a familiar phenomena (such as paper towel use). In addition, it is significant to note that students are not creating the products, but rather assessing them. In a sense, the Product Testing model is the inverse of the Protocol and Design Challenge models: rather than being giving a

[17] We should note that we are not arguing that such an activity is not worthwhile, but simple that it does not work as an effective design challenge.

protocol and asked to find opportunities to use them, students are given the objects and need to create the protocols to apply; rather than creating a product to meet certain criteria, students are asked to create the criteria to assess given products.

BLACK BOXES

Black Boxes challenge students to determine the nature of things hidden from view. They require students form logical arguments since they must reach conclusions without direct observations. Hence, overcoming the Variability Problem is at the heart of their nature.

Depending on their nature and context, Black Boxes can be used to highlight various concepts. The most common and broad is illustrating the difference between observation and inference. For example, the simplest Black Box activity is a literal box containing various objects, where students are challenged to determine the nature of the contents without opening the box. This also demonstrates how Black Box activities must not simply be puzzles, with one acceptable solution. Rather, the fact that one cannot directly examine the contents – its black box quality – means that the argument about the conclusion is even more essential than the conclusion itself.

Black Boxes can also be used to make more specific connections to atomic theory. They illustrate the ability to reach conclusions despite a lack of direct observation. For example, students can be challenged to determine the size and shape of objects hidden form view with marbles or other small balls, thus being analogous to scattering experiments. Other Black Boxes can be devised where some observations also change the object, hence simulating the Heisenberg Uncertainly Principle.

Black Boxes can also be used to illustrate modeling as a form of scientific inquiry. The Mystery Tubes exercise presents students with a tube containing various ropes. Pulling on a rope may (or may not) effect the other ropes. Students are challenged to create a tube of their own that mimics the behavior of the target tube, hence modeling the phenomena.

DISCREPANT PHENOMENON

Discrepant Phenomenon activities center around an distinct, non-intuitive, and often impressive, event, and naturally poses to students the question “what is going on?”.

The Ammonia Fountain (Shakhashiri, 1989) is an example of the Discrepant Phenomenon Model. Here, students see water rise up a tube and turn into a pink fountain. The cause challenges students’ common conceptions of suction. This also illustrates how Discrepant Phenomenon activities have a strong content connection.

The non-intuitive aspect is crucial for overcoming both the Getting-on-Board and Variability Problems. It helps make the question to students both meaningful and non-trivial. And it provides opportunities for multiple positions. However, an effective activity requires that the students experience the phenomena as discrepant. Whether a particular phenomenon has that discrepant quality is dependant on the context and the students. What is obviously problematic for one set of students might not be for another.

Many Discrepant Phenomenon Activities are done as a teacher led demonstration, for technical or safety reasons. However, they also illustrate how an otherwise teacher centered activity (the teacher is in control and doing the physical work of the activity) can be executed in an inquiry manner. And like the Protocol Model, the Discrepant Phenomenon Model provides a possible opportunity for turning traditional cookbook labs into inquiry activities.

The Discrepant Phenomena model is also a means to take advantage of novel circumstances and “teachable moments”.

INTRINSIC DATA SPACES

Intrinsic Data Spaces immerse students in a data space that inherently implies a question. They have a “sandbox” aspect that allow for easy exploration of the data. These overcome both the Getting-on-Board and Variability problems by presenting a natural puzzle.

An example of the Intrinsic Data Spaces Model is Mystery Bones. Student are presented with cut outs of bone fossils. Arranging the bones into possible animal formations is a natural task. Students can be further challenged to make conclusions the nature of the animal. Hence it should be pointed out that while the Intrinsic Data Spaces Model does depend on the natural draw of the data that does not need to be the full extent of the activity.

Simulated environments would be an important sub-category of Intrinsic Data Space activities. Such computer programs, such as Interactive Physics (Interactive Physics, 2005) or Stella (Stella, 2009) can be effective in allowing students the flexibility and freedom to explore (thus overcoming the Variability Problem) while lowering the technical and cognitive barriers (thus overcoming the Getting-on-Board Problem).

Taxonomical exercises would be another important sub-category of the Intrinsic Data Space Model. Categorization can be a natural routine with a given set of items. This is also a topic that tends to be taught in reverse – starting with categories – giving students the misconceptions that these categories are self evident and unproblematic. But starting without labels – such as giving data tables of a variety of solar system objects without names – can create a meaningful inquiry activity. Effectively overcoming the Variability Problem will depend on the number and range of item, in order to avoid funneling students to a predetermined conclusion.

SUMMARY

These categories are intended to outline different paths to attaining the student experiences seen as essential for scientific inquiry. Their differences should be viewed as an asset, as each has nuances that may be advantages in different pedagogical circumstances. For example, the Protocol and Discrepant Phenomena Models seem better suited to situations that have specific content goals, where as the Design Challenge and Product Testing are well suited where the nature of engineering processes is a learning goal.

While we see these categories as distinct paths to reaching the goals of inquiry, combinations are also possible. A Design Challenge with the ultimate goal of planning a long lasting public monument can begin with a series of Protocols around erosion. The Bioassay Protocols described above can be come a minor part of a Design Challenge to improve storm water filtration. Students can be introduced to the Stella computer modeling environment (Stella, 2009) as a Intrinsic Data Space through a series of mini-Design Challenges. These combinations allow instructional planners to take advantage of the features of the different categories and create a more authentic overall experience.

Lastly, it is important to understand that these categories are tools, not panaceas. Instructional planners must still be conscious and creative about the proper conditions to allow for student inquiry. In particular, achieving the right balance in defining the task and the data that students work with is very particular to both the activity and the audience.

IMPLICATIONS AND FUTURE RESEARCH

In this research, we hope to aid teachers and other instructional planners by both getting more specific about the forms inquiry can take than general goals and descriptions on the one hand, but on the other hand provide a more general framework than specific activities. The categories we have identified here contribute to further defining the problem space of inquiry design.

There are two critical threads of future research. First, it is important to continue challenging the robustness of this taxonomy. This can be done by holding it up to various sets of inquiry activities, and considering how well they are sorted. The result will either be a conformation or expansion of our categories.

Second, an important utility of having such defined categories is that we can then systematically examine and provide guidance on the details of instruction. For example, what are the important features that make a Discrepant Phenomena Activity work? As discusses above, we have begun to do this for the Protocol and Design Challenge Models.

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A VIEW OF MANAGEMENT IN AN INFORMAL EDUCATIONAL ORGANIZATION FOR PUBLIC AWARENESS OF SCIENCE: A CASE STUDY OF THE FIELD STUDIES COUNCIL IN BRITAIN

Shiho MIYAKE

Kobe College, Japan

miyake@mail.kobe-c.ac.jp

Tomoyuki NOGAMI

Emeritus Professor

Kobe University, Japan

ABSTRACT

Since the "Science Communication in Theory and Practice" was translated into Japanese and published in 2003, the movement of science communication widely occurred in Japan. However, there is a significant problem in this new movement. We have to accumulate the knowledge as concrete factors of how to establish a maintainable organization of the PAS providers. In this research, based on the case example of the Field Studies Council in Britain, it is considered that the characteristic issues of how the FSC managed its organization successfully as a provider of PAS by historical approach. It is also discussed the fundamental factors of PAS maintainable management based on the case study of FSC operation. As a result, it turned out that the FSC strove to be financial independence in the early period and finally succeeded in the measure aiming at the growth of the organization. In sum, it is recognized that considering a financial aspect can be regarded as a viewpoint of the PAS maintainable organization. While the viewpoint of financial aspect is important to focus on the maintainable organization, it is also required to scrutinize various types of PAS providers as case examples and to obtain practical suggestions about management to maintain PAS organizations and enterprises.

Keywords: *Organization management, informal educational facilities, Public Awareness of Science, the Field Studies Council*

INTRODUCTION

Since the "Science Communication in Theory and Practice (Stocklmayer, S. *et al*, 2001)" was translated into Japanese and published in 2003, the movement of science communication widely occurred in Japan. For example, museums and universities started to hold events explaining the latest science issues for the public people as their own enterprise. As one of the trend of science communication, the National Museum of Nature and Science set up a science communicator training course in 2006 (Ogawa, 2007). As well as this kind of museum enterprise, events of "science cafe" started to at local places. The science cafe is an event to provide a place where scientists and the public people talk together freely about science issues, drinking coffee or tea. It differs from the lecture meeting and academic symposium. By such trends, promotion of PAS is progressing step by step in Japan.

However, there is a significant problem in this new movement. According to Ito (2006), there is little idea how to establish a maintainable organization for the promotion of science. In fact, an organization of the “science cafe Kobe” run in Kobe city, is constituted by volunteer teaching staff members in Kobe University and supported by funds from the governmental auxiliary organization (Ito, 2006). This kind of enterprise may be difficult to carry out continuously, if the members’ motivation falls or funds are turned off. Therefore, not only carrying out events by the volunteer members with funds support, but also establishing a maintainable organization is important to promote PAS for the future. In this regard, we have to accumulate the knowledge as concrete factors of how to establish a maintainable organization of the PAS providers.

THEORY

As regard to the present situation of the PAS enterprise in Japan, it is necessary to research on the factors to investigate how to establish and maintain the organization of a PAS provider. However, in the science education research field, few studies focused on the organizational operation for the promotion of PAS.

While management study is few in science research field, there are substantial examples in art management for the promotion of art. The art management is a research area which discusses techniques for spreading art into society and leading development of art. For example, management of globally famous art institutions, such as the Metropolitan Museum, the British Museum, and the Sydney Opera House, introduced as case examples so far (Caldwell, 2000; Colbert, 2003).

Once, Layton (1984) explained the situation of how science was infiltrated into the society in terms of the establishment process of several associations, such as the Association of Public School Science Masters, the Association of Science Teachers, and the Science Mater’s Association. He mentioned the organization management of policy, human resources, and funds and described how each association was established and grew in the social relationship. However, investigating significant factors to maintain the PAS providers has not progressed to date.

Then, it should be important to make a first step for the PAS management research to obtain some suggestions by the outstanding example as a provider of the PAS enterprise.

PURPOSE OF THE RESEARCH

The purpose of this research is to find out the outstanding example as a provider of PAS enterprise and to extract the element of PAS management. In fact, the organization in overseas was focused on as a case example, since there is few organization in Japan that has been succeeded as a provider of PAS enterprise.

The Field Studies Council (FSC) in Britain is made into the case example in this research. The FSC is a charity organization to provide field study programs with the motto of “bringing environmental understanding to all”. It runs 17 field centers in the UK in 2010 (Field Studies Council, 2010). It was established in 1943 and has provided scientific fieldwork for both children and adults for more than 60 years. Today, the FSC is regarded as a pioneer of delivering academic field studies in Britain. In fact, Dillon *et al.* (2006) described that the FSC is an significant organization of field science provider in the UK. The current characteristics of undertakings and organization management of the council are explained that they correlate both with social education and school education (e.g Miyake, 2003a; 2003b; Baker et al., n.d.; Field, 2002).

This research will consider the characteristic issues of how the FSC managed its organization successfully as a provider of PAS by historical approach. It will be also discussed the fundamental factors of PAS maintainable management based on the case study of FSC operation. Then, finally, an implication for the present PAS enterprises in Japan will be explored.

METHODOLOGY

In order to extract the success elements of the FSC management, and discuss the fundamental factors of PAS management, data collection and research procedure are carried out as follows.

Data Collection

The author collected annual reports, which the FSC published every year since its establishment in 1943. From 2000 to 2005, the author went several times to the FSC head office and field centers, and obtained those annual reports. A total of 61 reports from the 1943 to the 2003 fiscal year were procured. Furthermore, when the author visited the FSC head office, interview about the present organization structure was carried out for the chief executive, Mr. Anthony Thomas.

Procedure

Based on data sources above, the following two issues will be discussed in this research.

1) Considering characteristic issues which encouraged the growth of the FSC

> First, the author divided the historical development process of the FSC into four terms as the dawn period (1943-1955), the construction period (1956-1968), the maintenance period (1969-1987), and the expansion period (1988-2004), and described characteristic issues in each period that encouraged the growth of the FSC (Miyake, 2009).
>
> Then, these characteristic issues are classified with a view of management. The view of management is made into four points as physical resource, financial resource, human resource, and information resource, which are interrupted by the museum management view of Ohori (2001) and Wilson (1989). Among these four resources, information resource includes information technology, networks and communications with other organizations. Therefore, in this study, the information technology is interrupted as intellectual strategy for communication with others.
>
> Based on these procedures, it is considered that how the FSC encouraged to grow as a PAS provider.

2) Investigating fundamental factors of the PAS maintainable management

> It is considered a significant view of PAS management to maintain the organizations, based on the characteristic issues of the FSC management.

RESULT: CHARACTERISTIC ISSUES THAT ENCOUTRAGED THE GROWTH OF THE FSC

The characteristic issues in the four historical period of the FSC are shown in Table 1. In this section, these issues, which are thought to be linked to successful maintenance and expansion of the FSC organization, are summarized in terms of the four management resources; physical resource, financial resource, human resource, and information resource.

Physical resource

First, there are five issues which link to the physical resource.

- Establishment of four field centers by voluntary work of ecologists and educationalists
- Quantitative and qualitative improvement of the field centers
- Establishment of a day center
- Establishment of the new field centers in Northern Ireland and Scotland
- Maintained appropriate learning environment that considers amenities and safety of users

These five issues show that the FSC secured field centers as the base for enterprise. The organization increased the number of centers and strove for the qualitative improvement of them. Even if a financial condition got worse in the construction period, the FSC was maintained all field centers without abandoning.

Financial resource

Second, there are three issues which link to the financial resource.

- Preparing for self-support accounting system
- Transition to the self-support accounting system from the grant-support system, because of the financial cut of the governmental support
- Increase the number of users of field study programs and field centers

It turned out that the FSC took the measure for carrying out financial independent management in the early period. The strategy to increase the number of users seemed to lead financial success of the organization, because the participation fee was the important income source. As a result of shift to the self-support account system from the grant-support system, the FSC had a critical phase to be independent.

Table 1. Characteristic issues through the historical periods of the FSC (Miyake, 2009)

Period	Characteristic issues
Dawn period (1943 - 1955)	1) Establishment of four field centers by voluntary work of ecologists and educationalists 2) Providing field study programs for amateur groups in the field centers' surrounding natural environment 3) Preparing for self-support accounting system
Construction period (1956 - 1968)	1) Quantitive and qualitative improvement of the field centers 2) Providing field studies for the students at secondary educational level 3) Publication of an academic journal: "Field Studies" 4) Transition to a self-supporting system from a grant-supporting system, because of the financial cut of the governmental support 5) Increase the number of users of field study programs and field centers 6) Training of academic staff members 7) Establishment of a research unit
Maintenance period (1969 - 1987)	1) Establishment of a day center 2) Promotion of field studies for the general public 3) Establishment of "units" in field centers 4) Implementation of staff training focusing on users' safety 5) Cooperation with international and domestic organizations
Expansion period (1988 - 2004)	1) Establishment of the new field centers in Northern Ireland and Scotland 2) Maintanance of appropriate learning environment considering amenities and safety of users 3) Providing educational programs for children and students that corresponded to the educational curriculum 4) Providing learning programs for the general public focusing on lifelong learning 5) Composition of the decision-making organization consisted of human resources having experiences in field center management and learning instruction 6) Field center management based on the discretion of the center directors 7) Hiring full-time staff members with professional skill of environmental science issues 8) Divided process development of field study programs 9) Environmental consulting conducted overseas

Human resource

Third, there are four issues which link to the human resource.

- Training of academic staff members
- Implementation of staff training focusing on users' safety
- Composition of the decision-making organization consisted of human resources having experiences in field center management and learning instruction
- Hiring full-time staff members with professional skill of environmental science issues

The FSC employed the persons with professional skill of environmental science issues as full-time staff members, and educated and raised them. The staff members who had on-site experiences in field centers were placed in the central decision-making section of the organization.

Information resource (Intellectual resource)

Finally, there are four issues which link to the information resource.

- Providing field studies for the school students corresponded to the education curriculum
- Providing learning programs for the general public focusing on lifelong learning
- Publication of an academic journal: "Field Studies"
- Environmental consulting conducted overseas

The FSC offered field study programs that followed school curriculum of national education policy. As well as to follow the education policy, it provided field study programs to attract the various interests of people in wide range of age group. Moreover, the FSC forged ahead to overseas through the publishing business and the consultancy business. In other words, the FSC expanded its enterprise as the result of the growth of the organization.

Characteristic issues in the history of the FSC

The characteristic issues, which lead maintainable management of the FSC organization, are shown as follows.

1) The FSC took the measure for financial resource to carry out financial independent management in the early period.

2) The FSC strove to maintain and to be rich in physical resource, without reducing the number of field centers.

3) The FSC employed the persons with professional skill of environmental science issues as full-time staff members, and educated and raised them as human resource.

4) The staff members who had on-site experiences in the FSC's field centers constituted the central decision making organization of the head office.

5) Field study programs follow the education policy as national curriculum and meet the various interest of a wide range age group of people.

6) The FSC advanced to the publishing business and the consultancy business as expansion of the enterprise.

DISCUSSION & CONCLUSION: FUNDAMENTAL FACTORS OF THE PAS MAINTAINABLE MANAGEMENT

In the above section, the characteristic issues that encouraged the growth of the FSC are outlined. This section will discuss the success factor of the FSC as a PAS provider and will suggest fundamental factors of the PAS maintainable management.

Success factor of the FSC as a PAS provider

The FSC was originally established by the voluntary peers of ecologists and educationists, and supported by the governmental funds at first. However, the financial support was cut soon. This would be the first point to become a maintainable organization, because the FSC had a strategy to be an independent organization after the financial crisis.

The outline model of strategy which led the growth of the FSC is shown as Figure1. First, the FSC strove to shift from the grant-support to the self-support accounting system. Then, considering tactics for ensuring income was necessary for the FSC. As one of the tactics, the FSC aimed to improve quality and quantity of the service.

The outline of the improvement are, for example, 1) developing a way of delivering field studies as physical resource, 2) corresponding with national policy as school curriculum and with demands of people as information resource, and 3) training of the staff members and setting on-site experienced persons to the decision making section as human resource.

In this regard, these contents of management resources seemed to lead the expansion of the FSC's enterprise. To sum up, the FSC strove to be financial independence in the early period and finally succeeded in the measure aiming at the growth of the organization.

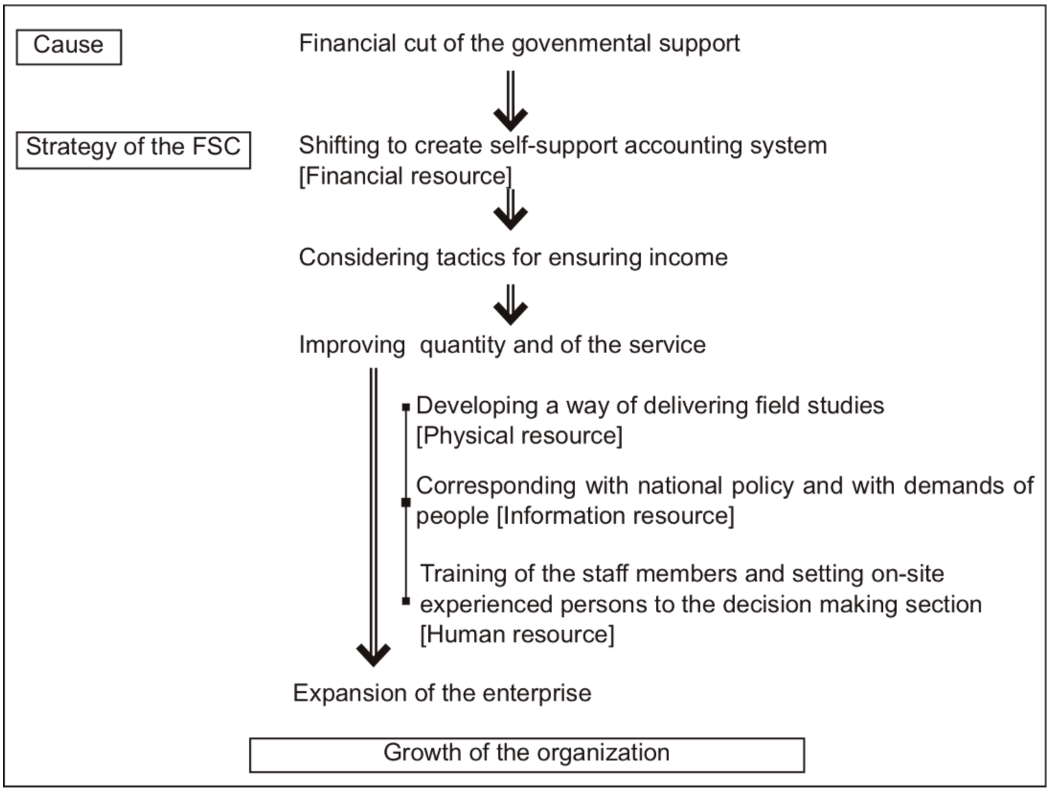

Figure 1. The outline model of strategy leading the growth of the FSC

Implications to the present PAS enterprises in Japan

By the result of historical survey, the present stage of the Japanese PAS enterprises seems to be the same as the early stage of the FSC dawn period. It is because volunteer members carry out the PAS enterprises as their optional work. This is the similar circumstance when the FSC was born at the dawn period in its history.

The difference cannot be compared clearly in the social system of the PAS enterprises between Japan and Britain only by the result of this research. However, if the viewpoint of the PAS organization management proposed by this research and suggestions from previous various research works are considered, implications for the Japanese PAS enterprises would be explored.

In Japan, institutions in the rich natural environment like field centers have been established since 1959 and managed by the national government. Their policy is aiming at planning and carrying out educational programs of outdoor activity through nature for young people (e.g. National Institutions for Youth Education, 2006). Although there is a program to look at flowers and creatures, there is no learning program to promote scientific and ecological understanding of the surrounding natural environment in these institutions. As well as this, there is accommodation to stay in the facilities, however there is no room for science-experiments. In this regard, the infrastructure of the PAS organization, which offers learning programs for natural science, has not been improved yet in Japan. Moreover, the promotion of science awareness to the public people was enforced in 1995 by the Science and Technology Basic Low. After that, the relationship between the driving actors and the target actors in the public of PAS was discussed (e.g. Ogawa, 2006). But the concrete idea of the sustainability of the public community for PAS has not been produced yet. These issues may suggest one of the reasons why the establishment of the PAS organizations in Japan has not be progressed yet.

On the other hand, in Britain, the trend of educational enterprises in terms of ecological and environmental science was set in the 17th century. For example, the Royal Society that is the organization of bearing natural history for people was established in 1660 (Royal Society, 2010; Allen, 1976/1994a). Moreover, Allen (1976/1994b) suggests that delivering outdoor natural science studies were stabilized as a market in the 19th century in Britain. This kind of social situation may promote to establish the pioneering organization like the FSC in the 20th century in the UK. In fact, by the case study of the development of the FSC, it is suggested that the "strategy to be financial independence" seems to lead maintainable growth of the organization. Therefore, it is recognized that considering a financial aspect can be regarded as a viewpoint of the PAS maintainable organization.
To sum up, it is considered that extending a field science study market and financial independent of the PAS groups are inquired to promote PAS as further social movement in Japan. However, the financial issue is not always a main goal for the PAS organizations, because the public facilities do not work only for their profits. There may also be influence of a substantial culture or political issue in the development of the PAS organization. Then, it is required to scrutinize various types of PAS providers as case examples and to obtain practical suggestions about management to maintain PAS organizations and enterprises.

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SOCIOCULTURAL AND HUMAN VALUES IN BIOTECHNOLOGY TERTIARY EDUCATION IN SOUTHERN AFRICA

Jean Mollett	Chrissie Rey	Ann Cameron
School of Molecular and Cell Biology/University of the Witwatersrand	School of Molecular and Cell Biology/University of the Witwatersrand	Science Teaching and Learning Centre/University of the Witwatersrand
jean.mollett@wits.ac.za	chrissie.rey@wits.ac.za	ann.cameron@wits.ac.za

ABSTRACT

It has been established that epistemological barriers play a significant role in effective teaching and learning. The aim of this research is to investigate the impact of African epistemologies, including sociocultural and human values, on learning in the field of biotechnology. The study intends to investigate what epistemological barriers there may be for the teachers and learners in the field of biotechnology at the Universities of the Witwatersrand in South Africa and the University of Namibia in Namibia, with the focus on facilitating capacity development through teaching at the tertiary education level. This study will hopefully provide a platform for the development of a biotechnology curriculum responsive to African needs and epistemologies. The value of this study lies in formulating and developing the biotechnology curriculum, and Teaching and Learning (T&L) of it, an 'African product', rather than as an export of decontextualised western science.

Keywords: *Biotechnology; cross-border tertiary education; African epistemology*

INTRODUCTION

Globally, universities, research institutions and industry work towards the development and application of biotechnology. Areas of interest include crop agriculture for food security, animal and human health and environmental sustainability. All these are of utmost importance, not only globally, but also in southern Africa. Consequently it is vital that the skills required for establishing biotechnology knowledge should be promoted through capacity training at tertiary institutions. Capacity development refers to the process whereby organizations and society adapt and maintain capacity over time. Capacity development therefore depends on progressive involvement in the field concerned and the achievement of high skills by those working in it. Tertiary education contributes to capacity development by training a country's human resources in fields relevant to its development (OECD, 2007).

Biotechnology has become one of the University of the Witwatersrand's (Wits) important research areas. This follows the global trend in this discipline, and in recognition of this trend, the University of Namibia (UNAM) has introduced new biotechnology courses into their curriculum. A project which involves regional co-operation through cross-border teaching and collaboration was set up between Wits and UNAM to help build up and strengthen existing biotechnology capacity at Wits and develop biotechnology capacity at UNAM (Mthembu, 2006). The project had its beginnings within a larger project called the South African-Norway Tertiary Education Development Programme (SANTED).

SANTED was a Norwegian-funded, government-to-government development project which ended in August 2009. Its major objectives were to enhance co-operation and build partnerships between Universities in southern Africa and to develop capacity in both the theory and applications of biotechnology through the introduction of relevant curricula and the strengthening of existing curricula. The outcomes of this project include (1) the introduction of biotechnology courses at UNAM, which were approved by the UNAM Senate at the end of 2007. These modules are in the 3rd and 4th years of the new curriculum and taught for the first time in 2009 and 2010; (2) the regional cooperation through cross-border teaching and collaboration between Wits and UNAM in developing the skills for the theory and application of biotechnology at the tertiary education level; and (3) the recognition of potential worldview differences i.e. western versus African. According to Cobern (1996) 'worldview' has to do with an individual's presuppositions about what the world is like and important knowledge about the world. A science worldview is concerned with acquiring knowledge through predictions. Such knowledge is regarded as universal, whereas from the perspective of an African worldview, knowledge is a gift from the ancestors. It is a social and tribal entity which is not regarded as universal (Hamminga, 2009). This paper will describe the process of this project so far, and is a continuation of the paper presented at the 2008 IOSTE symposium, which described the SANTED project and the workshops involved to enhance co-operation and build partnerships in tertiary institutions in 3 countries in the Southern African Development Community (SADC).

LITERATURE REVIEW

This literature review is made up of three sections which provide the background for this research. These are biotechnology, epistemology and tertiary education. The first section, comprising **the nature of agricultural and plant biotechnology (APB) in southern Africa,** addresses the status of biotechnology in South Africa and Namibia; biosafety concerns; and the legislations, policies and regulatory frameworks in place. The next section, **the nature of epistemology**, looks at African epistemology and traditional ecological knowledge. The final section, **the nature of science in tertiary education,** gives a brief overview of cross-border education and how an understanding of African epistemology can lead to a culturally sensitive curriculum.

The nature of agricultural and plant biotechnology (APB) in southern Africa

Biotechnology in South Africa

South Africa has a history of engagement with traditional biotechnology. This has led to one of the largest beer brewing companies in the world (South African Breweries) and to the development of excellent wines (Ngubane, 2001). In addition to alcoholic beverages, it has also led to the utilization of its natural plant and animal diversity, for example the protea and kwagga breeding programmes and the National Research Foundation Indigenous Knowledge Research programme encouraging academics to look at medicinal plants. Traditional biotechnology has been practiced by indigenous peoples in southern Africa for centuries, as in the brewing of local beers from sorghum or marulas, and to the mating of cattle to produce particular colour patterns. Modern biotechnology, however, requires the use of carefully controlled laboratory procedures which are only available as a result of modern science and scientific procedures. Modern biotechnology involves manipulating DNA, and refers to the use of genetically modified (GM) organisms in agriculture and industry (Campbell and Reece, 2005). South Africa is now the 8th highest producer in the world of genetically modified foods, planting more than 1.8 million hectares of GM crops in 2008 (GMO Indaba, 2009). S.A. is at the forefront of the research on crops of both economic and cultural importance. These crops include various cereals: maize, wheat, sorghum, millet and soybean; various vegetables: cassava, yam and sweet potato; various other economically important fruits and flowers (Brink et al., 1998). GM crops are now grown by both commercial and small-scale farmers. APB techniques include tissue culture programmes established for application in root and tuber crops and ornamental and horticultural crops; genetic engineering projects (both public and private) for the commercial growth of insect-resistant maize and cotton and herbicide-tolerant soybeans and cotton; marker-assisted selection is applied in maize and small-grain breeding; molecular diagnostics and markers are used for plant disease diagnosis; biological nitrogen fixation is applied in soil fertility improvement by using legumes and inoculants.

Legislations, policies and regulatory frameworks in South Africa

South Africa has developed APB to a position where infrastructure and regulatory frameworks are adequate to facilitate Plant Genetic Engineering (PGE) as well as the commercialization stage of GM crops. South Africa has a legally-binding Genetically Modified Microorganisms Act (Act no.15 of 1997) and the country adopted the National Biotechnology Strategy in 2001, which created a policy framework to establish incentives for the biotechnology sector, and led to the establishment of Biotechnology Regional Innovation Centers (BRICs) throughout the country. These centers function to conduct and fund biotechnology research and to introduce initiatives to encourage international partnerships. The formation of the regulatory framework permitted the commercialization of existing knowledge from biotechnology research (Brink et al., 1998).The South African Department of Science and Technology’s (DST) ten year innovation plan (2008-2018) aims to drive transformation towards a knowledge-based economy, in which the construction and propagation of knowledge leads to economic benefits. One of the grand challenge areas of the DST, the “farmer to Pharma” value chain, aims for South Africa to become a world leader in biotechnology and pharmaceuticals, based on the nation’s indigenous resources and expanding knowledge base.

Biotechnology in Namibia

In Namibia the types of APB techniques that are used include Tissue Culture for producing cassava and Irish potato and for micropropagation and disease elimination. Serological techniques and biological Nitrogen fixation is applied for legumes.

Namibia participated in a research project coordinated by John Innes Centre, Cambridge University, United Kingdom, involving the enhancement of pearl millet for downy mildew resistance (http://www.wisard.org?wisard/sharedsp/StrCountrySelect.asp?CountryA2+NA). This project was completed in 2003 and involved the fine-mapping and isolation of genes underlying downy mildew resistance in pearl millet through breeding schemes of selected lines together with the characterization of quantitative trait loci for resistance (http://www.cababstarctplus.org/abstracts/Abstracts.aspx?AcNo=20043053248). Namibian research teams together with teams from South Africa and Europe have worked on projects investigating the development of insect resistance in important African crops such as Bambara groundnuts and Marama beans and fungal resistance in millet (ABSF AFRICA, 2009).

Legislations, policies and regulatory frameworks in Namibia

In Namibia the Biosafety Bill was passed in 1999 and since the signing of the Cartenega Protocol on Biosafety in 2000 and the endorsement thereof in 2005, biotechnology has gained ground. The Namibian Biotechnology Alliance (NABA, 2004) is a forum that is involved in developing and promoting biotechnology use and research within Namibia. It developed the National Biosafety Framework in 1998 and has done research into "Awareness in Biotechnology and Biosafety" and "Identifying the agricultural needs that could be solved through Biotechnology" (NABA, 2004). The Ministry of Agriculture, Water and Rural Development administers the Biotechnology research policy for Namibian APB development. Namibia do not import any genetically modified products and have a strict border control which requires a certificate, possible tests and rejection if the product is genetically modified

(http://www.fao.org/biotech/inventory_admin/dep/country_rep.asp?country+NAM.).

The nature of epistemology

African epistemology

According to Bakari (1997) African epistemology is characterised by strong interpersonal relationships, peace with nature, communalism and spirituality. This epistemology places emphasis on ethics and morality, symbolic imagery, self-awareness and tradition (Bakari, 2007). Indigenous African epistemology has both geographical and cultural factors that contribute to an African identity (Higgs, 2007). Relevance and usefulness remain central to the African philosophy. Community and belonging to a community of people is also very important to traditional African life (Higgs, 2007).

Higgs (2007) refers to African community-based research and he argues that the indigenous African epistemologies for research in higher education are centred in communalism, where a community is described as a number of people who have something in common that distinguishes them from others. This can be geographic, language, ethnic or religious identification. African community-based research is process oriented and it aims to strengthen the knowledge that exists in a community.

In countries where people of European descent coexist with indigenous people, especially where the indigenous people are in the minority (United States, Canada, Australia, and New Zealand), their systems of indigenous knowledge have been almost or completely destroyed due to them having undergone a "culticide" through the colonizer's educational systems (Van Eijck and Claxton, 2009). In Africa, knowledge is culture-laden and this knowledge is generally passed on verbally through generations where it is more about preserving existing knowledge and wisdom from the past, rather than generating new knowledge. It is not given much attention in formal science classrooms. Van Eijck and Claxton (2009) encourage science educators to overcome trends in science curricula that discourage indigenous minorities in sustaining their worldviews and they encourage students to consider how technology-based topics reflect moral principles and virtues that are part of their lives.

Traditional Ecological Knowledge

Instead of seeing science as a universal way of knowing, there are many who adopt a cultural perspective that treats science as a human practice relating to Traditional Ecological Knowledge (TEK) (Snively and Corsiglia, 2000). TEK refers to how humans come to understand the natural world around them. It is a term coined to describe knowledge attained through time and patient observation of the natural world – it can have 'science' in it, but connections made may be out of the sphere of western science as it is defined, i.e. through evidence and experimentation (Van Eijck and Claxton, 2009).

If we unpack the term Traditional Ecological Knowledge (TEK), "Traditional" refers to a cultural continuity transmitted through social attitudes and beliefs derived from historical experience. However, as societies or communities change over time and adapt to their environment by adopting new practices and technologies the typical definition of "traditional" becomes difficult to formulate, and the term "ecological knowledge" is also difficult to formulate especially since ecology is defined as a branch of biology in the area of western science. Some authors prefer the term Indigenous knowledge (IK) to TEK as it puts the emphasis on indigenous people. TEK and/or IK refers to knowledge acquired over thousands of years of human contact with the environment, and sometimes this is information that is passed on orally and it is shared only if it will not be used for gain (Snively and Corsiglia, 2000). Science lecturers at the tertiary level in Africa are often educated in foreign countries or they are educated following a western curriculum in their home countries and therefore know more of Western modern science (WMS) than their own indigenous sciences. The Global Education Digest 2009 reports that one out of every five foreign students from Africa is studying at a South African university (10 168 from Namibia). According to this study one of the reasons they leave their home countries is because of under-resourced universities (Govender, 2009).

The nature of tertiary science education

Cross-border tertiary education

Internationalization of higher education is described as "the process of integrating an international intercultural and global dimension into the purpose, functions (teaching, research, service) and the delivery of higher education". Internationalization activities apply to cross-border projects and campus-based activities. Cross-border tertiary education falls within educational internationalization and refers to the movement of people, programmes, providers, curricula, projects, research and services across national or regional jurisdictional borders (OECD, 2007). UNAM and Wits are the first southern African institutions to consider cross-border tertiary education as a helpful capacity development tool in plant biotechnology. However, a consideration of African epistemological access should inform this cross-border tertiary education capacity development.

According to Laugksch (2000), in education the term 'scientific literacy' equates to the development in a person of the ability to understand the nature of scientific knowledge, to use science in solving problems, and to appreciate the connections between science and technology, and between these two and society. Science and technology tertiary education in southern Africa is offered in multicultural classrooms where different views of science may be firmly rooted in certain cultural assumptions. This influences how students formulate and solve problems (Stanley & Brickhouse, 2000). Students of different cultural backgrounds can interpret science concepts differently, indicating that teachers should prepare a science curriculum suitable for use in a multicultural classroom by using the prior knowledge that the students bring to class. Snively and Corsiglia (2000) argue that the curriculum should recognize a community's indigenous knowledge or worldview in a way that creates a need to know Western science, i.e. by including IK and WMS content to study certain fields of interest more thoroughly, thus enriching understanding of the environment in a sustainable way.

METHODOLOGY

With the introduction of biotechnology courses at UNAM, the regional cooperation through cross-border teaching and collaboration between Wits and UNAM was set in motion. This involved team teaching where a Wits representative visited UNAM to share scientific knowledge in the area of plant biotechnology principles and techniques involving genetics and microbiology, together with issues around genetically modified organisms (GMOs). This topic covered plant genomes, the organization and expression of genes, plant tissue culture and techniques for plant transformation, vectors for plant transformation, the expression and stable inheritance of transferred genes, together with safety and environmental considerations. This was accomplished in 7 one hour lectures throughout a week in the second semester of 2009. Communication across borders in southern Africa is very slow and setting up the week of lectures took 2 months of email contact.

As this study is intended to investigate issues of epistemological access which will inform cross-border teaching and learning in Biotechnology through the process of co-operative capacity development at the tertiary education level in the two diverse, multicultural universities. A qualitative design is used because qualitative research is flexible and concerned with process, and understanding the process (Merriam et al., 2003, Merriam, 1998). The research process continually evolves and unfolds, because the study seeks to understand a dynamic and continuously evolving process (Merriam et al, 2003). In researching epistemological access, the research function is to describe the different worldviews of the teachers and learners involved and whether they lead to epistemological barriers. The research will involve a case study approach in which the methodology of Design Research will be employed (Leedy and Ormrod, 2005; Plomp, 2008) using a worldview theory as the theoretical framework (Cobern, 1996). The worldview theory provides the environment for examining the reasoning and thinking of teachers and learners.

Design Research is an alternative research approach. Plomp (2008) uses the term 'design research' as a common label for a group of related research approaches which vary a little in goals and characteristics e.g. design studies, design-based research, developmental research, formative research and engineering research. The search for 'understanding' or 'knowing' is the key focus of any scientific research, and it aims to add to the body of knowledge or theory in the field of the research. The broad focus of educational design research is to provide 'insights and contributions for improving practice', and to enlighten decision making and policy development in the field of education (Plomp, 2008).

Usually in a case study a global issue is explored through a specific case (Merriam, 1998), i.e. biotechnology is becoming a major research thrust globally and in this specific case, the development of biotechnology capacity in southern Africa at the tertiary education level. In a case study, a program or individual is studied for a defined period of time (Leedy and Ormrod, 2005). In order to gather worldview and epistemological information, a semi-structured interview format will be used, together with questionnaires for assessing worldviews of biotechnology teaching and learning images.

The data will be analyzed inductively using the constant comparative method (Merriam et al. 2003; Glaser and Strauss, 1967; Strauss and Corbin 1998). This method of data analysis involves comparing concepts or categories coming from one data set with concepts from another data set , and then looking for relationships and themes between these concepts until "analytical 'saturation'" is reached (Badenhorst, 2008). Triangulated data collection which involves researching the same research question from more than one source of data will be gathered from the two institutions in the form of semi-structured interviews, observations and questionnaires.

Participants

For this paper, which is the implementation of a long term project, the participants include two of the lecturers involved in teaching the biotechnology courses at each institute and the learners are a convenience sample from the 3rd year students in the Department of Biological Sciences at UNAM (currently 22 registered). Ethical clearance has been obtained for this research and the information obtained from students and lecturers involved in biotechnology will be used to inform a culturally sensitive biotechnology curriculum in future.

Reliability and validity

Tacit and formative theories have an effect when collecting qualitative data (LeCompte, 2000). Tacit theories could bias information, as they guide daily behavior, explain the past and predict the future. Formative theories are more formal and used in research, although they also guide behavior, create explanations and predict the future (LeCompte, 2000). Transforming data into research results is called analysis. Good analysis is based on clearly articulated theories, and responsiveness to research questions. Creating meaningful results involves validity, or whether or not research findings seem accurate or reasonable to the people involved in the study. Validity also refers to whether or not results obtained in one study can be applied to other studies with similar situations (LeCompte, 2000).

According to Badenhorst (2008) the traditional criteria for judging quantitative research are internal validity, external validity, reliability and objectivity and the parallel alternative criteria for judging qualitative research are credibility (how truthful the findings are), transferability (how relevant the findings are to other settings), dependability (how consistent and reproducible results are) and confirmability (how reflective of all involved parties are the findings).

The latter four criteria are applied in research designs through triangulation, which involves researching the same research question from more than one source of data. Campbell and Fiske (1959) introduced the concept "triangulation" as a synonym for convergent validation, meaning that information from different sources can be used to substantiate and illuminate the research problem and therefore limit any biases, personal or methodological. Denzin

(1978) identified 4 types of triangulation i.e. data triangulation, method triangulation; investigator triangulation, and theoretical triangulation. Data and method triangulation will be applied in this research.

RESULTS

The 2009 cohort of 20 third year undergraduate students were the first to be introduced to the new biotechnology courses that were discussed and planned at the SANTED curriculum development workshops held at WITS in 2006 and 2007. There are two third year biotechnology courses in this new curriculum, i.e. Recombinant DNA Technology, which was taught in the first semester and Biotechnology, which was taught in the second semester.

A questionnaire on this "SANTED week of lectures" as it was called, was completed by the students and the UNAM lecturer involved, for feedback to SANTED. They were conscientious in answering the questionnaire answering all the questions and carefully unpacking the information. Although the students are taught in English, they have a variety of different home languages i.e. Afrikaans, Damara, Damara-nama, Oshiwambo, Oshindonga, Otjiherero, Rukavanga, Rukwangali, and Setskiana, which highlights their cultural diversity. Defining the term 'biotechnology' is not an easy task, since it can mean different things to different people, as it is connected with various needs and interests. Through their answers the students showed that they had very distinctive ideas of the term biotechnology and what it meant to them. These students had attended a semester of Recombinant DNA Technology and two weeks of this module called Biotechnology. Ten out of fifteen respondents felt that it could improve society, provide treatment for disease and provide food security. Of the other five students, two felt that it could improve agricultural production, generate income and be of economic use, and the other three gave definitions of the term. This was the first time biotechnology topics were being taught at UNAM, so students were asked when their first biotechnology learning experience had been. Most students referred to the topic experience they were involved with at the time. One student mentioned baking bread and watching the dough rise and that they also felt excited about bananas without seed, and red oranges. Students were very open and frank and said their motivation to learn biotechnology came with the fact that it was now part of the curriculum, so they had to do it, but they all liked the idea. One student even took it as far as wanting to be a good scientist and "change Africa from poverty". Students felt they were learning biotechnology when they were learning the genetics and microbiology background, and when they were involved in practical laboratory work. These practical laboratories involved extracting DNA from cells. The students also enjoyed seeing the practical results of other students' work, for example the third year practical results from Wits laboratories. This week of plant biotechnology was interesting for them and they felt they had gained additional and empowering information. Their answers to their motivation to do biotechnology highlights that they did not directly choose it as a subject but just ended up having to do it as part of the curriculum. However, they felt it would have opportunities for them. The following quote by one of the students sums it up: "Genetic manipulation and transformation section really change my life to do biotechnologies (sic)".

The students enjoyed all the modules and sections on biotechnology they had done. They had very positive comments about the "SANTED" week. They found it "very useful" and learnt many new concepts about plant biotechnology they had never realized before. The students felt lecturers from other universities contributed to their learning "as they teach differently” and “bring different knowledge”. Some seemed to feel that UNAM was less advanced and lecturers from other universities would be up to date with the current scientific world. Another opinion was that we “could all share our knowledge and learn new things by having lecturers from other universities”. Yet another felt that it is a way of “learning about each others cultures” and sharing “traditional norms and values”. One student felt that “knowledge is power and biotechnology is one of them”. Another wrote that armed with this knowledge, he or she felt they could “now have a conversation with other lecturers”, which shows how empowered the students felt by this new curriculum and the SANTED experience of a ‘lecturer from across the borders’.

The common theme that was evident from the lecturer’s and the students’ responses to the questionnaire, especially with regard to SANTED, is that they were very positive. It empowered them to know they were learning what other students learn at other universities; they enjoyed the exposure to a different teaching style; and interacting with the information they were being introduced to. They liked the idea of lecturers from other universities teaching them as it made them feel confident about what they were taught, giving them a sense of security about the knowledge they were acquiring. This shows the effect globalization has already had on the way these students view and receive knowledge.

CONCLUSION

The students felt enriched by this experience and quotes from the questionnaires bears testimony to this: “I really enjoyed this week. It made me see the real application for biotechnology” and “Thank you for an educative and informative week!” These are just two of the many comments that highlighted the worth of the week for the students. The broad focus of educational research is to provide ‘insights and contributions for improving practice’, and to enlighten decision making and policy development in the field of education (Plomp, 2008). The lecturers involved at Wits and UNAM and the Pro-Vice Chancellor, Administration and Finance, of UNAM indicated that they would like to see biotechnology capacity development and the sustainability thereof.

African community-based research intends to integrate indigenous African knowledge systems, founded on indigenous cultural and social values, with modern knowledge systems, while simultaneously exposing indigenous communities to scientific knowledge production and dissemination (Higgs, 2007). From this initial interaction it is evident that in southern Africa globalization is implicated and accepted in the development and application of biotechnology, especially from the economic point of view of food security, animal and human health and environmental sustainability. In accommodating student and lecturer input we hope to be able to include African knowledge systems with modern knowledge systems in creating a new curriculum which will be in keeping with southern African sociocultural and human values.

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BRIDGING THE GAP: THE ROLE OF EXPERIENCES IN INFORMAL EDUCATIONAL SETTINGS AS PART OF INITIAL CHEMISTRY TEACHER TRAINING

Bruno Andrade Pinto Monteiro

Universidade Federal de Lavras

bpmonteiro@ufla.br

Isabel Martins

Universidade Federal do Rio de Janeiro

isabelmartins@ufrj.br

ABSTRACT

The argument that science education can be fostered by actions in both formal and informal educational settings has been increasingly put forward by the research community in the context of discussions about the need to promote scientific literacy. Such perspective challenges teachers who were trained in traditional programmes. Based upon Bakhtin's account of the role of language in understanding the social practices and on Bourdieu's concept of cultural capital this study analyses the discourses of a group of chemistry teachers about informal education. Preliminary results obtained through textual analysis reinforce the relevance of the theoretical framework and reveal multiple voices in beginning teacher's discourses about the role of teacher, school settings and informal education. Accordingly, we believe that the science teachers, or educators traditionally trained to act in formal education are facing new challenges, for example, the task of developing practices of science education in contemporary educational places made possible by approximation of the formal and informal spaces of science education.

Keywords: *teacher education, museums, discourse analysis.*

1. INTRODUCTION

The argument that science education can be fostered by actions in both formal and informal educational settings has been increasingly put forward by the research community in the context of discussions about the need to promote scientific literacy (HONEYMAN, 1998; GOUVÊA et al, 2001; FALK, 2002; QUEIROZ et al, 2002; GRUZMAN & SIQUEIRA, 2007). From this perspective, the Declaration of Toronto (TORONTO, 2008), a document elaborated in the last World Congress of Science Centers in June 2008 presents a series of goals, guidelines and beginnings that should orientate the actions of the Museums and Science Centres. In this text it is possible to notice that there is a high recognition of the educational function of the MSC by society which represents a change in the perspective that restricts function of Museums and Science Centres to scientific popularization. According to the document, besides promoting scientific literacy, Museums and Science Centres constitute inclusion spaces and of social change that possess influence in education and in the development of society. In this paper we argue that science education can be favoured by the articulation of actions in formal and informal environments and describe a teaching sequence whereby teachers in initial education programmes in Brazil have experienced and discussed the possibilities of planning, implementing and evaluating activities in the school and in museum. The idea was to prepare future teachers to the challenges involved in integrating students' experiences in and outside school.

Studies by Queiroz, Gouvêa and Franco (2003) diagnosed that practicing teachers who accomplished school activities in the Museu de Astronomia e Ciências Afins (MAST/ Brazil) recognized the importance of the articulation among informal spaces and school.

Nonetheless, they reproduced a traditional school pedagogy during museum visits with their students. (QUEIROZ, GOUVÊA & FRANCO, 2003). The authors' literature review stresses that initial teacher training programmes in Brazil do not prepare teachers to benefit from what museums and science centres have to offer. This is problematic because there are statistical data to confirm that, unlike students from carreers of greater social prestige such as Medicine and Odontology, future teachers tend to come from low income backgrounds which have limited access to cultural heritage (e.g. theatres, cultural centers, museums, art galleries, music rooms, libraries etc.) (CAZELLI, 2005). In this way, we think that there must be concrete opportunities in initial teacher training programmes for these future teachers to acquire social and cultural capitals necessary to fully explore the potential of museum and science centres in their teaching practice.

2. THEORETICAL FRAMEWORK, METHODOLOLY AND RESEARCH QUESTIONS

In this work, we presented the first stage of our research conducted with a group of 22 beginning Chemistry teachers from the Federal University of Lavras. The investigation involved the identification of discursive changes in the students' discourses during a four month (68 hours) course on the role of informal educational spaces and their relationships with school. The course involved readings about (i) the relationships between education and culture; (ii) the notions of cultural heritage and scientific culture; (iii) the role of museums and science centres as promoters of scientific literacy; (iv) descriptions of activities integrating experiences in formal and informal educational environments. The course also included four guided visits to science museums and the elaboration of a teaching sequence to be implemented by the beginning teachers. The sources of data of the research consist of the texts elaborated by the beginning teachers (paper/book reviews, field notes, essays, answers to questionnaires etc.) and of videorecordings of classroom activities and of museum visits. Follow-up interviews were also conducted and transcribed *verbatim*. Our analyses sought to identify textual marks that reveal how these 22 beginning teachers interpreted and understood the possibilities of integrating activities in formal and informal educational environments.

The investigation was based upon theoretical concepts of the philosophy of the language, especially on the contributions of Bakhtin, and in concepts of Bourdieu's sociology. We understood that the situations produced in the spaces of initial teacher training programmes can be understood as a group of institutionalized and located social activities in cultural atmospheres. They provide a socio-conceptual horizon from which positions are taken and points of view are constructed. Utterances, for Bakhtin (1988), are influenced by external factors and the situation and the most immediate participants determine their form and the style. We will therefore seek to establish relationships between beginning teachers' utterances and features such as their socioeconomic background, their views about science and society and their readings of materials that circulated during the course. Besides, we understand that the texts and speeches produced by the beginning teachers are constituted by a plurality of other speeches. The vision of Bakhtin considers that the texts are constituted by different "voices", that is to say, in the act of production of an utterance the speaker incorporates countless social positions they represent the plurality of representations, points of views, values, conceptions etc. With reference in those theoretical presuppositions, we are mainly interested in identifying and in characterising discursive marks that demonstrate which social voices constitute our beginning teachers' discourses, how they are present in their speeches and if they contain references to voices of official speeches that mark ideological positions in relation to the role of the teacher, of the school, of museums and science centres and, also speeches that demonstrate epistemological visions of the Science. Bourdieu (1998) reiterates the need to consider the social conditions and power relationships in the analyses of the linguistic phenomena. The contact point between Bakhtin and Bourdieu enables the interpretation of the beginning teachers' discourses in the social context of their production, that is, in the context of an experience set up as part of formal education. This perspective points out that, during the interactions which happened during the course and in the visits to the museums, meanings were negotiated between the participants. For Bourdieu, in the verbal interactions between individuals or groups there are confrontations between ideologies and each one tries to impose their *"categories of perception of the social"* world through argumentative efforts (BOURDIEU, 2007). This is why our empirical data consists of verbal expressions generated in different social contexts.

However, a challenge of this study refers to the fact that, according to Cazelli (2005), cultural spaces like museums and science tend to be seen by the low income population as spaces which belong to the elites and that are legitimated by social processes, for example within the family or during school socialization, that distinguish groups and individuals with respect to the ownership of symbolic and material cultural capital and by the constitution of different *habitus*. (CAZELLI, 2005). This author reiterates that *"to visit theaters, cultural centres, museums, art galleries, music rooms, libraries are not part of the cultural horizon of disadvantaged groups in society"*. (CAZELLI, 2005). Social representations concerning museums and science centres can, in this way, reproduce power relations of the economically favoured classes that control the access to the cultural heritages. We understood, through both direct observations and analysis of preliminary data, that this could be the case for the beginning teachers who were subjects of this research. For this reason we tried to create concrete opportunities and support material for them to take part in the activities that required critical observation of environments they might not be familiar with or, worse, felt intimidated by.

Starting from this theoretical framework and problematisation, this research to understand, in the context of a particular educational experience set up as part of an initial teacher training programme, aspects concerning:

(i) the relationships between future teachers' sociocultural conditions and their possibilities to consider articulations between educational practices involving schools and museum and science centres;
(ii) the social voices that are present and which constitute future teachers' discourses about possible relationships and possibilities of teaching science through the articulation of activities in school and in informal settings
(iii) the understanding that beginning teachers possess about: the teacher's role, the relationships between schools and museums and science centres, epistemological conceptions of science; curriculum recommendations etc.

In order to explore these points we will discuss relationships between two sets of data: beginning teachers' answers to a socio-enconomical questionnaire and textual analyses of an essay written by them during the course. The analysis will explore relationships between their socio-economic profile, their expectations and their appropriations of ideas that integrated texts presented and read during the course.

3. RESULTS AND DISCUSSION

3.1 EVALUATION OF SOCIOECONOMIC PROFILE GROUP

It was possible to map out the socio-economic profile of the subjects of the research according to their answers to a socioeconomic questionnaire filled in at the start of the course. The beginning teachers who took part in the study reside in the southeast of Brazil, in the central state of Minas Gerais. About 45% of the students came from cities with population range between 10.000 to 60.000 inhabitants around the city of Lavras, where the university is. Seven were male and 15 female, and their age varied between 21 and 25 years old. The total family income of approximately 52% of the students is below U$ 800,00 and the main occupation exercised by the member of the family that more contributes to that income is related to the administration of own businesses. The respondents also informed that they were not frequent goers to museums, galleries of art, concerts, dance/ballet presentations etc. as most of them happened in the capital of the state which is 300 km away from the cities where they live. In other words, most of the beginning teachers informed to have limited access to both material and symbolic cultural equipments (CAZELLI, 2005).

3.2 ANALYSIS OF TEXTS PRODUCED BY THE STUDENTS

A first analysis of the texts produced by the beginning demonstrated the presence of several social voices, related to different educational discourses. The texts are therefore heterogeneous and polyphonic, in the sense that they indicate discursive markers of points of view associated to different sociocultural horizons, related to discussions about teachers training and to new demands faced by science education. Our analyses started with the examination of an essay written by students at the beginning of the course about what they felt were the possibilities offered by informal educational settings in the teaching of natural sciences..

As we can exemplified below in box 01 that shows a fragment of Carla's text, there is a clear recognition that school is not the only possible or productive setting as far as science education is concerned. Carla points out three examples, museums, computer science laboratories and open fields, and stresses the need for specialized knowledge which would enable teachers to benefit from their full educational potentials. This vision agrees with views expressed by educators from museums and science centres that were present in texts discussed during the course such as work of Cazelli et al ideas that students should not be limited to the school environment 2002) and texts by Gaspar (2002) which discuss new possibilities for the development of educational practices in multiple settings.

> "Several settings can be used for the education in sciences: museums, computer science laboratories and even an open field. It is just a matter of knowing how to explore the potentials of each setting".

Box 01. Fragment of Carla's essay.

Carla goes on to point out that both schooling and experiences provided by the teachers may have a role in ensuring accessibility of students to museums. This idea alludes to the discussion undertaken by Castro et al (2001), on the difficulties faced by people living in conditions of social exclusion in their daily lives. This author states that these young people are deprived of taking part in social networks that revolve around the cultural assets of society.

> "[...] A visit to a museum, for example, can provide access to an area never visited before, that may never have been visited because of lack of information and/or opportunity".

Box 02. Fragment of Carla's essay.

References to 'traditional methodologies' were also frequently deemed negatively and associated to many initial teacher training programmes:

> "The traditional education based on the booklet `chalk and talk' is weak though still present in many courses.

Box 03. Fragment of José Carlos' essay.

In box 04 below, Carla mentions relevant aspects that reveal her views about 'traditional' science lessons. As we can see, there is an implicit view of science education as associated to scarcity of teaching resources, knowledge transmission and negative attitudes towards science. Cazelli et al discuss such ideas in relation to aspects of standard liberal-traditional pedagogy, where "education is focused on the teacher who, before an audience considered as *tabula rasa*, transmits orally in an organized manner and with the help of audiovisual resources, a set of consolidated universally accepted contents" (Cazelli et al, 2002). Carla points to the need to explore other resources, apart from blackboard, chalk and books, but does not go as far as criticizing the epistemological bases of standard universalistic content-based approaches to the teaching of science. Another interesting aspect is the conflicting views that Carla brings about in her text concerning a negative depiction of "terror" that obscures the beauty of science education. It is interesting that such an association suggests that the climate of terror, imprinted in these disciplines may be attributed to factors linked to teacher's actions or to the school environment itself, since the science education is seen as inherently beautiful.

> "So the teaching of science should not be like it was years ago: blackboard, chalk, teacher and book. It is possible and necessary to explore other areas to make the subject matter more interesting and so that the "terror" that surrounds the disciplines of chemistry, physics and mathematics is left aside and students can see the beauty of science education.

Box 04. Fragment of Carla's essay.

In the fragment presented below, taken out from Solange's essay, there is also a reference to the role of the teacher who adopts 'traditional' approaches and their consequences. The articulation of experiences in schools and in museums and science centres is, in this context, clearly considered as an innovation and Solange's texts refers to a widely available image of both conservative and authoritarian behavior followed by many teachers who are reluctant to incorporate new methods and approaches in their practice. At the same time there is an acknowledgment of the role of research in changing this image.

> "[...] Large scale projects and research are taking away that image that the science teacher is as an authoritarian person who goes to the classroom only to 'spit' contents over students."

Box 06. Fragment of Solange's essay.

This image, which is decontextualised from historical considerations that might account for the roots of teachers' resistance to change, does not take into account limiting factors that can explain why the implementation of new approaches may not be so easy in some cases. However, some of the essays written by the beginning teachers also expressed views about aspects of teaching as a profession, namely, remuneration, work conditions, social status etc. that could have an impact on the kinds of activities and possibilities to implement changes that explore articulations of experiences in formal and informal settings. Unfavorable social perceptions as well as the low status attributed to teaching in society are reasons to justify teachers' difficulties to promote changes in such direction. In the fragments of texts presented below, taken from the texts produced by other students, we find projections of social horizons and values about the current role of teachers and of teaching:.

> "[...] Teachers, especially those in public schools, do not feel encouraged to promote changes in their classrooms due to the devaluation of teaching both financially and in terms of the professional ideals. Apart from this he often finds himself as hostage of the student.

Box 05. Fragment of Elaine's essay.

In this fragment from Elaine's essay, in box 05, she recognizes the existence of a process of devaluation of public school teachers that affects their motivation and self-confidence. Also, when referring to the depreciation of ideals, she suggests that teachers are not confident about their capacity of being promoters of social change through education. In addition, Elaine uses the hostage metaphor to characterize the relationship between teacher and students as they face the harsh realities of the school setting. This idea alludes to the work of Zagury (2006) where the author argues that contemporary forms of intra-family relationships and the absence of limits for children have led to the fall of the teacher's authority at the same time, transferred to educators disciplinary functions traditionally performed within the family. According to Zagury (2006), factors such as indiscipline and lack of motivation of the students have become the greatest problems of the schools. From this perspective, the teacher became a sort of hostage *"[...] suffering internal pressures of the system - which drives him to implement techniques and methods that will require dedication almost every individual student - and he can not, why not "have time"; From the very consciousness that reveals their inability to conduct a qualitative, as it is currently recommended; Of the students, who now face the challenge openly and in many cases, students' families, who lost his authority over the children and urged the school to do so in its place; The company, which now and then surprised teachers and administrators with precautionary measures, injunctions and processes [...]".* (ZAGURY, 2006). All these factors were presented as obstacles to planning and implementing alternative teaching strategies that might involve visits outside schools and, together with the lack of support, makes it more difficult for them to afford the necessary structural and intellectual investments to experiment with new approaches and methodologies.

4. CONCLUSIONS

The fragments of texts presented above represent a small sample of a wide range of texts produced by students during the course. Most of them, in the texts produced at the beginning of the course, wrote about the educational potential of museums and science centres but, at the same time, problematised the lack of access that both disadvantaged students and underpaid school teachers might have to such places. This discourse echoes voices such as that of Castro et al (2001) who studied the lives of youngsters who face situations of social exclusion and are out of the networks around which cultural goods gravitate. They also think that in such informal learning environments it is possible to provide more positive experiences with science, where students can see the "beauty" of scientific knowledge as opposed to unpleasant classroom experiences commonly associated to failing Science and Maths at school. The majority of texts written after the course beginning teachers widened the scope of the debate and empahsised role of museum visits as instrumental to enabling classroom discussions of aspects related to (i) the history of science; (ii) contemporary science; (ii) socio-scientific issues. Despite that, exhibits and apparatus seen in museum and science centres were often described as illustrations of the subject matter, a point also criticized by Queiroz et al (2003). Only one teacher elaborated on the risk of assuming a naïve attitude towards museums and science centres as places of entertainment. Some teachers portrayed museums in an excessively idealised way, as being always stimulating and interesting, as opposed to traditional classroom teaching, in a way that might lead to an undesirable devaluation of the role of the school. The next step in our analyses relate to a problematization of how these different social voices present in the beginning teachers' discourses engage in symbolic dispute.

As part of research on training of science teachers, we find that there are still many studies that question the issue of possible relationships between schools and the Guest. In our review of the literature on this subject we find very few works about this issue. Thus, we hope to provide contributions that enable further discussions and actions that bring to the degree possible new approaches to teaching science.

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GIMNAZIJA VIČ STUDENTS' SCIENCE PROJECTS IN COOPERATION WITH RESEARCH INSTITUTIONS

Alenka Mozer

Gimnazija Vič, Ljubljana

amozer@siol.net

Darko Dolenc

Faculty of Chemistry and Chemical Technology, University of Ljubljana

darko.dolenc@fkkt.uni-lj.si

Mojca Čepič

Faculty of Education, University of Ljubljana

mojca.cepic@ijs.si

ABSTRACT

At Gimnazija Vič in 2006, based on students interests and in cooperation with different research institutions, a special science project was introduced; the most motivated students in the field of science and technology were invited to enroll on the so called "science class". Through the years, an effective way of inquiry based science learning was introduced in every class at the school level.

Science courses are anchored by students' experimental tasks which are carried out under the mentorship of their teachers and/or researchers. The main goal of the project is to improve students' knowledge through the student centered learning and to increase interest of young people in science and technology. The project is fully incorporated into the regular high school curriculum.

The aim of this study is to provide evidence for the effectiveness of the new teaching approach. Students' results at the national final exam were evaluated. Difficulties the teachers and the researchers faced were revealed.

The results clearly indicate that inquiry based science learning and possibilities to work and learn under the mentorship of researchers significantly influence the better quality of students' knowledge and have an important impact on choosing their studies in the field of science and technology.

Keywords: *secondary school science, student centered learning, research education cooperation, inquiry based science learning*

INTRODUCTION

Since the origins of the declining interest among young people to study science are found largely in the way science is taught in schools, the European Commission has tasked several groups of experts to examine the field of science education (GRID 2006b). From on-going initiatives some important common elements of know-how were drawn which could bring a radical change in young people's interest in science studies. Effective long-term research education cooperations are established when there is a possibility of formal agreements based on financial support (Form-it 2007; Lernort Labor, 2009; Robert Bosch Stiftung, 2009, Sparkling Science, 2009). Several examples of good practice show similar characteristics - the role of experiments and practical experiences in the teaching and learning of science is crucial (Euler, 2003). Inquiry-based science education has proved its efficacy in increasing children's and students' interest and attainments levels while at the same time stimulating teacher motivation (Buczynski, 2010; Science Education Now, 2007).

Using constructivist classroom culture in science education young people are motivated to increase interest in different areas of science and technology (Tobin, 1998, Marentič Požarnik 2004, Plut Pregelj, 2008). The understanding of scientific phenomena is developed through students' activity and by appropriate communication among students, teachers and researchers. In school, science courses should be taught in an interdisciplinary way and adapted to the students' cognitive stage (Urbančič, 2007).

At Gimnazija Vič in 2006, based on students interests and in cooperation with different research institutions, a special science project was introduced. The project was initiated by Gimnazija Vic on the basis of 15 years of cooperation with the School in Experimental Chemistry (SEC) at Jozef Stefan Institute and several other research institutions. The main goal of the project is to improve students' knowledge through the practical experience. By introducing young people to the important field of research in science also a positive impact on choosing their studies at university is expected. Given its focus on understanding, science courses are anchored by inquiery based experimental tasks. Students are defined as bearers of in-class activities, as well as out of classroom activities carried out under the mentorship of their teachers and/or researchers at universities of applied sciences, research institutes, and industrial research laboratories and in institutions for popularization of science.

Science courses are focused on active teaching methods, interdisciplinary approaches and hands-on activities. Students tasks/projects are fully incorporated into the regular high school curriculum and/or the science subjects curricula.

Through the school year, students are involved in science projects (individual or team projects) which are carried out under the mentorship of their teachers and/or researchers at different institutions; besides that science days, lectures/discussions on interesting science topics, excursions, field trips and science weeks/research camps are organized. Students' contributions and presentations are assessed in class according to the criteria defined at the beginning of the project/research work; observations of the processes/students' work and the student's points of view are an important part of the assessment.

A team of science teachers has the main responsibility of planning students' activities. Students are mainly involved in identifying interesting topics to be carried out as their project/research work. A catalogue of possible topics to be researched has already been put together by the mentors.

Researchers are involved according to the students' fields of interests and according to the topics in science curricula. The first contacts among researchers and school were established on personal connections mostly, by years a network is building up.

These activities have a strong impact on the teachers who are constantly improving their teaching strategies and didactic approaches. Although the project was initially ment to be limited to the "science classes" only, the teachers were encouraged by the results, and this effective way of embedding inquiry based science learning into the subject curricula was introduced in every classs - at the school level.

The aim of this study was to explore the effectiveness of the new teaching approach at the end of a four-year ongoing project from two points of view:

- The first goal was to show that the students who were actively involved in learning activities/tasks/projects adopted a positive attitude towards the subject; a comparison on intrinsic motivation for learning science subjects and on active learning approaches in the classroom between 1st and 4th "science" classes and the 1st year and 4th year population was made on the basis of a short questionnaire.
- The second purpose of this study was to bring evidence of the impact on students' science achievements at the national final exam (matura) and in increase in the students choice of science subjects as their optional matura subjects since the project was started.

According to the educational researchers (Pintrich, 1999; Devetak, 2009), we also believe that the science project tasks presented a positive challenge to most of the students; they had an opportunity to research a topic they had chosen based on their curiosity and interests; last but not least the possibilities to work and learn under the mentorship of the researchers brought an added value to the students' knowledge.

METHODS

The overall students' results at the external national final exams (matura) in science subjects over a period 2003-2009 were compared to the Slovenian average results. Over the same period the number of students choosing science subject as their optional matura subjects at school was examined.

The results from a short questionnaire on active learning approaches in the classroom and on intrinsic motivation for learning science subjects designed by the authors in 1st and 4th/last year classes were analyzed (six 1st year classes – 183 students, six 4th year classes - 180 students). Since 2006 on, the most motivated students in the field of science and technology are invited to enroll on the so called "science class" (one out of six classes in the generation; 33 students in the 1st year, 30 students in the last year). The results from the questionnaire in the "science classes" were compared to the results at the school level.

We acknowledge that the example provided above is not representative in scope, but it was elected to provide a constrained example in this paper in order to illustrate the features of our research approach.

RESULTS

As mentioned above, at Gimnazija Vič an efficient model has been developed how to embed inquiry based science learning into the school/subject curricula. From the school year 2006/2007, one out of six classes in generation is formed on students' interest in the field of science subjects (approximately 32 students out of 190).

Questionnaire on intrinsic motivation and on active learning approaches results

To get relevant data on intrinsic motivation, the students were asked how much they had been interested in and how much they had enjoyed learning biology, physics and chemistry on the scale from 1 to 5 (5 - the best). The results are shown in Table 1.

Table 6

GRADE	1	2	3	4	5
1st year students					
Biology	12	32	47	66	26
Physics	14	18	49	55	47
Chemistry	15	28	35	57	48
1st year science class students					
Biology		9	8	10	6
Physics		3	3	15	12
Chemistry		1	4	8	20
4th year students					
Biology	15	41	49	53	22
Physics	9	29	46	61	35
Chemistry	12	25	48	56	39
4th year science class students					
Biology	3	2	9	14	2
Physics	1	2	5	14	8
Chemistry			1	12	17

The figures show that 1st year population is slightly more motivated than 4th population for all three science subjects; a shift at higher grades is noticed. As expected, the 1st and 4th "science" class students are far more motivated in science subjects than the overall 1st and 4th year population.

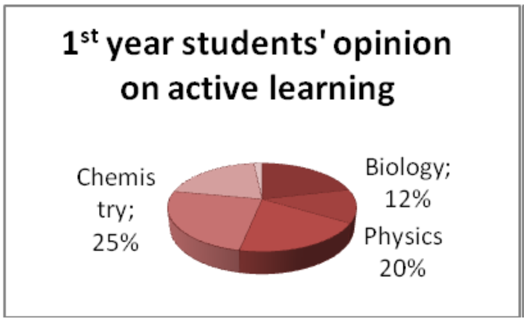
The differences in intrinsic motivation for learning all three science subjects are not significant for the 1st year overall population; however in the "science class" results show different. Although these students were highly interested in the field of science in general, after only half a year in the school, a drop in motivation for biology is noticed. This is also confirmed by the results from 4th year students' population. Again, the differences in students' interest in biology compared to the other two science subjects become greater and more evident in the "science class" (in 2006, with these students the project was started).

By opinion of the teachers, a part of the reasons for that origins from the biology curriculum in Slovenian high schools. Since similar problems (but not to the same extent) were detected on the national level, curricula changes and improvements are planned by school authorities.

On the other hand, although the biology teachers support the project, they are not as enthusiastic and involved due to some objective reasons (among others severe health problems). At Gimnazija Vič, there are two full time teachers (and one part time teacher with less than 0,4 teaching engagement) per science subject, so teacher problems directly reflect on the classroom practice. These results also show the need the teachers have for assistance in implementing new didactical approaches by professional educational organizations.

Based on the results, it can be concluded that a shift from classical teaching approach to the inquiry based one was made more successfully by chemistry and physics teachers; this is clearly pointed out also by the results of the question on students' involvement in the classroom. Students were asked to make an opinion on active learning approaches in biology, chemistry and physics courses by choosing one (or two) out of the three science subjects. This is shown in Table 2 (1st year students' results from the questionnaire on active learning) and Table 3 (4th year students' results from the questionnaire on active learning).

Table 7



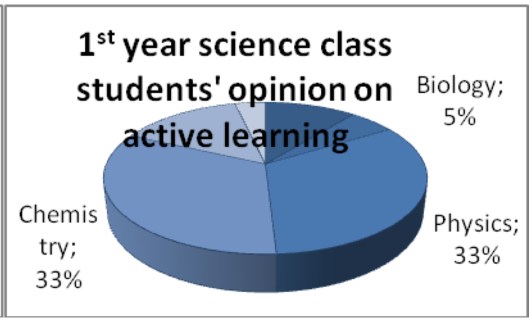
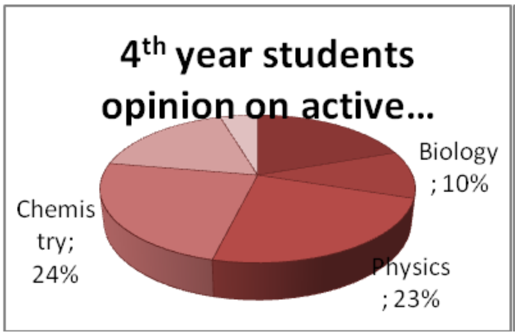
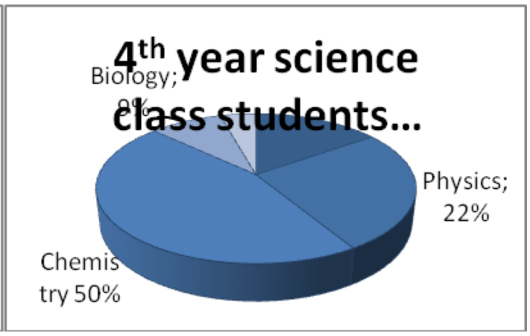


Table 8





The differences between chemistry and physics courses compared to the biology course are significant in both, 4th and 1st year classes; this is even more evident in the "science classes". As mentioned above, by students' opinion the physics and chemistry teachers are more committed to teaching for students' interest and learning, to active teaching methods, interdisciplinary approaches and hands-on activities than biology teachers.

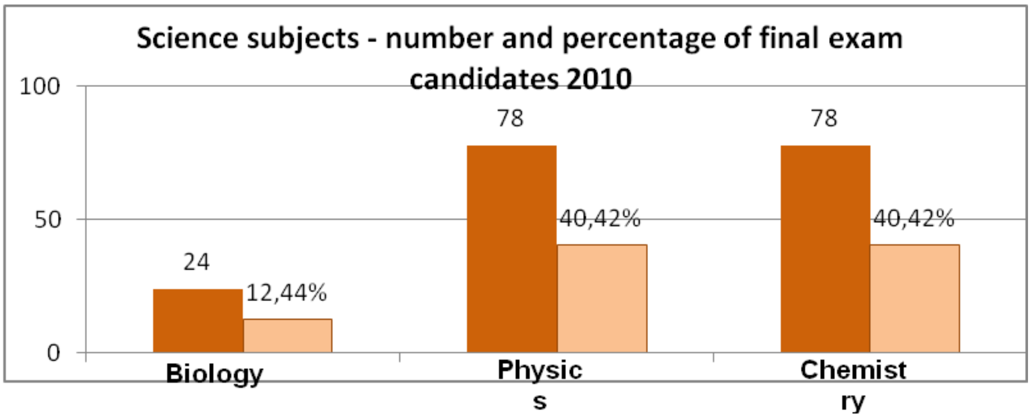
The degree of change seems to be related to the teachers' beliefs about teaching and learning. Teachers need to be willing to move from a lecture-oriented classroom to the student-centered classroom that engages students in inquiry. However, this must be examined in further investigations.

Students' results at the national final exams in science subjects 2003-2009

The results obtained from the questionnaires were also confirmed by the results at the external national final exams (matura) in science subjects. The school national final exam results in science subjects over a period 2003-2009 were compared to the Slovenian average results.

In June 2010, this first generation of the "science class" students will be taking national final exams. We believe that as a consequence of the project, in 2010 a significant increase of the number of students choosing science subjects as their final exam optional subjects has been noticed at school. In Table 4 the number and percentage of the final exam candidates in 2010 are presented.

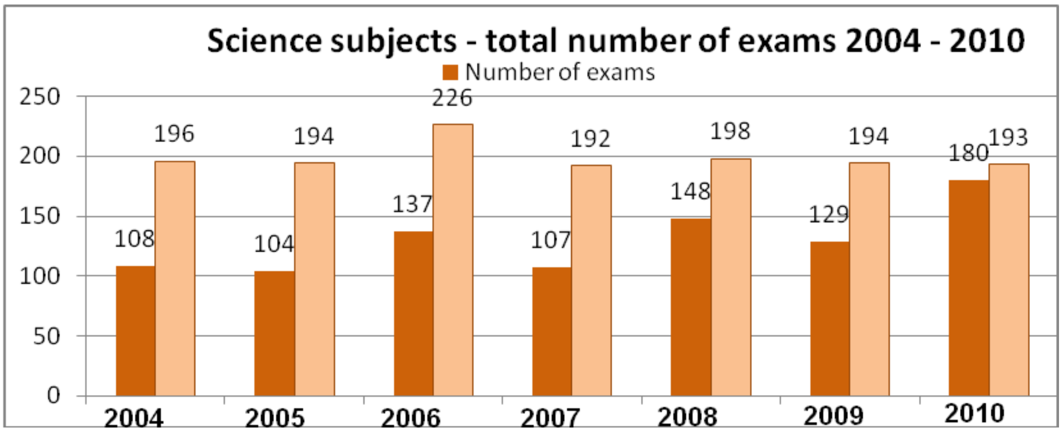
Table 9



Again, it is confirmed how important the role of the teacher is. Although formally team approach is used in all three subjects, physics and chemistry teachers are far more efficient compared to the biology teachers. In physics and chemistry, inquiry based instruction, teaching for students interest and learning, the use of active teaching methods, interdisciplinary approaches and hands-on activities encourages the students' external motivation, which is later on turned into internal motivation based on positive experiences. Thus, the new teaching approaches did not contribute to an increase in the number of biology students, and teachers probably neither apply methods nor perform activities through the course to an extent that would be significantly different from the classical classroom approach.

The number of the science subject exams which students choose as their optional matura subjects over the period 2004-2010 at school was examined; this is shown in Table 5.

Table 10

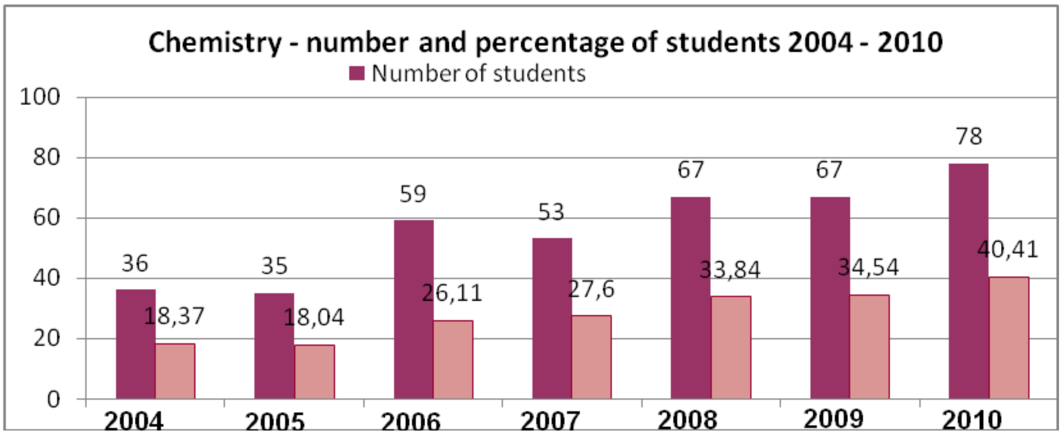


(In 2006, there was an exception of 7 graduate classes - 223 students compared to the usual 6 graduate classes per year, which is approximately 190 students).

Based on the results, it can be concluded that the number of science subject exams compared to the number of students is increasing. Special attention should be paid to the dramatic growth in 2010. Since students' choice of the optional final exam subjects is directly related to their choice of studies, we expect the students' generation 2010 to enroll on the studies in the field of science and technology to a much greater extent than the average Slovenian population.

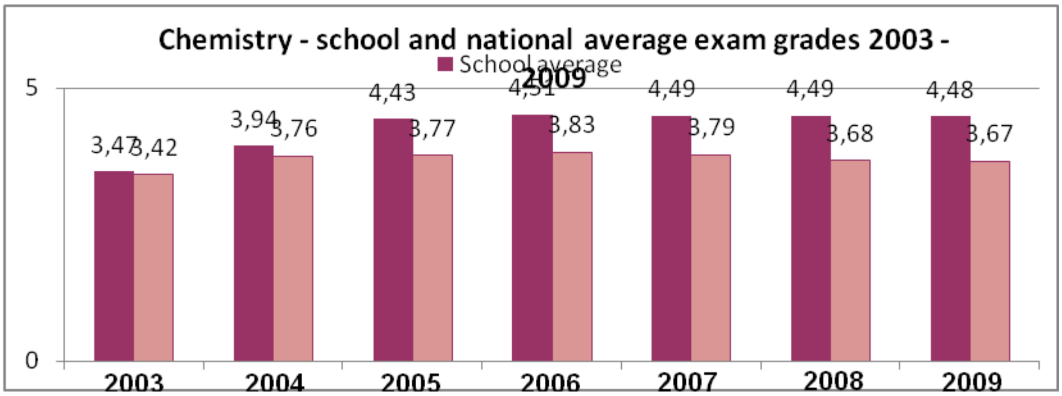
In Table 6, the number and percentage of chemistry final exam candidates over a period 2004-20010 are presented. The whole science project was initiated on the basis of positive experiences of the chemistry teachers, who were almost for 15 years productively cooperating with the researchers at several research institutions.

Table 11



The growth of the number of students is constant due to the fact that at school, the same teachers are teaching chemistry for almost 12 years and the team approach was agreed upon 8 years ago. As Table 7 shows, chemistry school final exam grades are always above the national average grades.

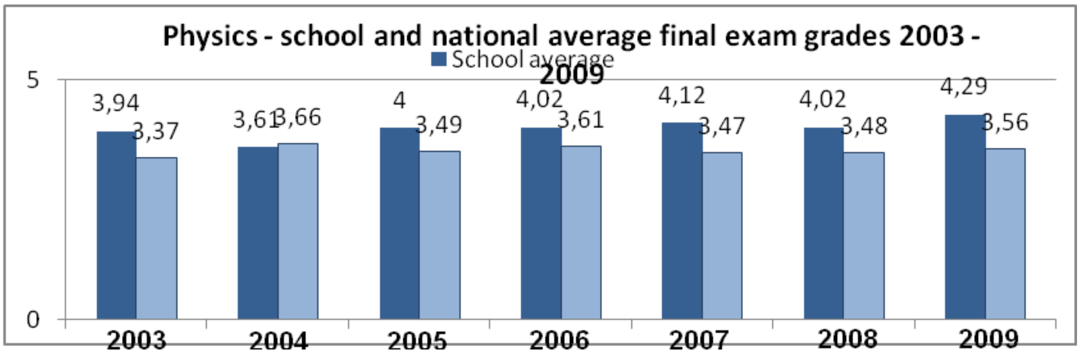
Table 12



Students' achievements are improving every year compared to the national average grade; this is important considering the fact that the number of students in the chemistry final course is increasing.

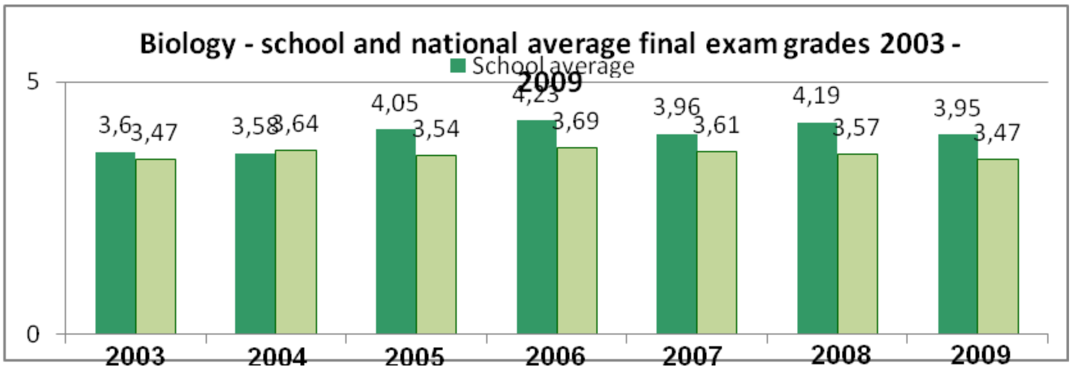
The physics final exam population and matura results (Table 8) show similar tendencies as in chemistry. Encouraged by positive experiences, more and more "academically weaker" students are taking chemistry and physics as their optional final exam subject.

Table 13



Although the biology average grades at the final exam are also very high (Table 9), the number of the candidates is much smaller and thus less relevant to this study.

Table 14



CONCLUSIONS

Implementing student-centered inquiry based science teaching in higher secondary schools is identified as an important goal by educational professional organizations; however it is rarely put into practice. As mentioned above, at Gimnazija Vič an efficient model has been developed how to embed inquiry based science learning into the school/subject curricula. The school results clearly indicate that inquiery based science learning and possibilities to work and learn under the supervision of researchers positively influence the better quality of students' knowledge. We believe that as a consequence of the project, in 2010, a significant growth in the number of students taking science subjects as their optional final exam subjects is noticed. We would like to emphasize that more and more "academically weaker" students are taking part in these courses.

Although the project was initially ment to be limited to the "science classes" only, encouraged by results, this effective way of inquiry based science learning was introduced in every classs - at the school level. This model will be presented and evaluated also in other Slovenian higher secondary schools.

Through the project, teachers were and still are improving their teaching strategies and didactic approaches, their science content knowledge and by this they also build up their competencies. A full co-operation of researchers from universities of pure and applied sciences, research institutions and industrial laboratories with teachers was established.

Some difficulties in these cooperations originate from the lack of possibility for formal agreements based on financial support, which provides the materials and the time needed for the menthorship of the students' projects. The main issue seems to be a complete lack of incentives and systemic support on the national level which causes problems of planning longterm activities.

These activities have a strong impact on school development; Gimnazija Vič is considered as an outstanding school in science subjects on national level. Our students take part in young researchers competitions, competitions in science subjects knowledge and achieve great results on national and international level. Last but not least, a positive feedback information is given on our students' knowledge from the faculties of pure and applied sciences, medicine, pharmacy…

Popularization of science and introducing young people to the important field of research in science and technology has an important positive impact also on choosing their studies in this field. Since students' choice of the optional final exam subjects is directly related to their choice of studies, we expect the students' generation 2010 to enroll on the studies at the faculties of pure and applied sciences, pharmacy… and other studies in the field of science and technology to a much greater extent than the average Slovenian population. Further investigation will be focused on the improvement of the model that has been developed. The impact of the links of the school with the researchers and industry will be explored, how it brings added value to students' knowledge and how it helps them make decisions on their studies and future jobs.

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SOCIO-CULTURAL & HUMAN VALUES, SCIENCE & TECHNOLOGY, AND ASSESSMENT: AN IMPOSSIBLE MIX?

Graham Orpwood

York University, Toronto, Canada
gorpwood@edu.yorku.ca

ABSTRACT

An emphasis on science, technology, society and environment (STSE) has become a part of science and technology curricula in an increasing number of countries over the past decade. This has challenged science and technology educators to rethink their teaching methods to address socio-cultural and human values in ways that had never been considered in the past. Teachers and students have had to address issues where knowledge and values interact in complex ways, where knowledge from a variety of disciplines is involved, and where new skills of deliberation and analysis are called for. However, as has been the case in previous "curriculum revolutions", assessment methods have been slow to catch up with changes in curriculum and teaching. This time, as assessment has become ever more important in most countries, the lack of adequate assessment methods threatens to derail the entire movement. This presentation outlines this dilemma, illustrates it with concrete examples, and suggests some ways forward.

Keywords: *STSE, values, assessment, validity, politics*

BACKGROUND

Two trends have been of increasing importance to many countries in recent years. The first has been the development of the curriculum to include not only knowledge of subject disciplines, and the skills associated with each discipline, but also understanding of the role this knowledge plays in the personal and public lives of individuals and societies. The second trend has seen the growing use of assessment – particularly international assessments (such as TIMSS and PISA) – as indicators of the effectiveness of schools and educational systems.

This paper argues that these two trends are on a collision course and that, unless educators can move rapidly and creatively to design new and appropriate methods of assessment, the government-sponsored trend towards more accountability-motivated assessments will overcome the academic and professionally sponsored trend towards addressing the relationship of socio-cultural and human values with science and technology.

CURRICULUM TRENDS

I have argued elsewhere (Orpwood, 2001) that changes in the science curriculum over the past 100 years can be seen as a sequence of revolutions and new paradigms (Kuhn, 1962). Continuously, the *content* of the science curriculum – "what" should be taught and learned – is developing and changing and debates over such content change are part and parcel of what can be described as "normal curriculum change".

Overlaying this normal curriculum change, however, have been two periods of what can be thought of as "curriculum revolutions" where the very *purposes and goals* of the science curriculum have been changed. Like the paradigm shifts Kuhn invented to explain the growth of science, these curriculum revolutions fundamentally changed the way that the science curriculum content should be taught and learned. They also signalled radical changes in curriculum policy and also textbooks, curriculum debate and research. Roberts

(2010) in an in-depth analysis of competing visions of scientific literacy, has talked of these as changes of “curriculum policy image.”

The first revolution began in the late 1950s and early 1960s when the aim of the science curriculum moved from a focus on science content for its own sake to include attention to the nature and processes of science. This was the period during which major projects funded (in the US) by the National Science Foundation and (in the UK) by the Nuffield Foundation attempted to redirect the teaching of science.

The second period of revolutionary change began in the late 1980s and early 1990s and added the emphasis on science, technology, society and the environment (STSE). Once again, the science curriculum was fundamentally transformed and made relevant not only to those who would be future scientists but also to future citizens and to those who were entering the world of work. Once again, science literacy was redefined, teacher education transformed, textbooks rewritten, and new agendas for research developed. This revolution took place at different times in different countries and in some places, is only now beginning to occur.

This is where Socio-cultural and Human Values (SHV) began to play a new and important role in the science curriculum. Once we began to see science and technology not just as disciplines of knowledge, or as systems of intellectual and professional inquiry, but also as having significant impact on practical decision-making both private and public, then SHV became closely entwined with science and technology. In the public sphere, issues involving energy, the environment, the economy, and appropriate limits to technological development all command attention. And in the area of private decision-making, the use of cars or public transit, and issues of nutrition and health are but two of the ways in which science and technology interact with SHV in the lives of individual citizens. The challenge of this latest curriculum revolution is to teach young people how to address these issues and to help them develop understanding of the roles science and technology play, both as sources of problems and sources of solutions.

However, throughout the past 50 years, as these two revolutions have changed much in science education, assessment has developed at a much slower rate. The first significant performance assessments – matching the emphasis on skills and processes that was fundamental to the first curriculum revolution in the 1960s – did not appear until the early 1980s in England (APU, 1983) and it was not until the late 1990s before performance assessment became relatively common in North America. Indeed, such assessments are still only now making their way into many countries for the first time.

Performance assessments – where students are given a practical scientific or technological task to accomplish and their skills at inquiry or design are observed and evaluated – are still not endorsed by many assessment specialists as they are hard to design, expensive to implement, and complex to score. The first round of the Third International Mathematics and Science Study (TIMSS), for example, included a performance assessment component. It was initially required for all countries wishing to participate in TIMSS; then, as the project developed, it became optional, and finally its results were published separately a full year after the reports of the written tests (Harmon et al. 1997). Performance assessment was subsequently dropped entirely from later iterations of TIMSS.

Assessments appropriate for the second curriculum revolution – the trend towards incorporating SHV into the teaching of science and technology – have yet to be developed on a large scale. Over the years, a variety of projects incorporating an emphasis on Science, Technology, Society and the Environment (STSE) have appeared throughout the world (Solomon & Aikenhead, 1994). Glen Aikenhead (2006) describes how two main approaches to assessment have been used in these projects: one is a traditional quantitative type of assessment and the other has been a more qualitative or “interpretive” approach to understanding students' knowledge. He adds that "emphasis in science education research has clearly shifted to interpretive studies" (p. 92). While such interpretive studies are clearly valuable in probing students thinking as they deal with issues involving science, technology and SHV (and therefore in evaluating the projects themselves), they cannot meet the demands of formal assessments required by educational systems. There are notable exceptions (two of which we shall review later) but these cases are far fewer than the "curriculum talk" in the journals might suggest.

On the international front, TIMSS tried and (in my view) largely failed to develop an assessment that was both a valid and reliable quantitative measure of science literacy. PISA has made more progress, though Fensham (2007), Sjoberg (2007) and others have made cogent, critical comments on the validity and success of this initiative also. Yet the international prominence of both of these studies has had significant political impact in many countries.

In summary, while the science curriculum in many countries is reaching forward to embrace Socio-cultural and Human Values (SHV) and to enable young people to understand the impact of science and technology on their lives, assessment in science education is largely looking back to an earlier age when the goals of science education were focused on knowledge of the disciplines, for the purpose of preparing young people for science at university. This might not matter, if assessment was not of great importance (both to students and schools) but this is also changing. So I will now turn to examine the second trend: the growth and change of the uses of assessment in education.

ASSESSMENT TRENDS

Assessment of student achievement has always been an important part of the educational scene but, in recent years, we have seen remarkable growth, both in the amount of assessment activity and in the variety of its purposes. This has led to observers analyzing these purposes and commenting on the conflicts arising when many players – each with their own agenda – undertake it. Some years ago, I noted the failure to resolve this diversity of purpose within the TIMSS assessment of science literacy (Orpwood, 2000). More recently, Gordon Stobart (2008) describes how examinations at the end of compulsory schooling began as a relatively straightforward system for certifying individual students and admitting them to postsecondary education but have since morphed into systems of school accountability involving "league tables" based on the proportions of students obtaining high grades. Stobart concludes with what he calls his Principle of Managerial Creep: "*As assessment purposes multiply, the more managerial the purpose, the more dominant its role*" (Stobart, 2008, p.15).

Now for managerial purposes, the overriding criterion for a good assessment (apart from its cost) is that it be reliable. Reliability in testing means high levels of precision, fairness and reproducibility. Since students, schools and countries are being compared with each other (and sometimes also with themselves over time), it is essential that the measures that form the basis for these comparisons be absolutely reliable. Much effort is therefore expended in national and international assessments to ensure this reliability: pretesting of items to determine their psychometric characteristics, elimination of items that do not seem to "fit" the item analysis model being used, careful training of markers to ensure consistency in marking for items that require subjective assessment, and so on. At the end of the day, the test may not measure precisely what it intended to measure but whatever is being measured is being measured very, very accurately.

By contrast, the curriculum developer and the teacher in the classroom, who are developing or using assessment for learning, are less interested in the reliability of there assessment (at least in a strict psychometric sense) and much more concerned for its validity: "Does the assessment correspond to the aims and content of the curriculum?" The (UK) 21st Century Science web site expresses the point well:

> As in all aspects of science learning, assessment is crucially important because it makes teaching and learning objectives clearer than anything else does. This is not simply the observation that 'teachers teach to the test'. It is the deeper point that any statement about learning objectives has to be operationalised in order to pin it down. We have to say what observable action by the student, perhaps in response to a task we set them, will count as evidence that they have achieved the learning we want them to achieve. (21st Century Science, 2008)

Both validity and reliability are important criteria of good assessments, of course. But for managerially-motivated assessment, reliability will always trump validity and for learning-motivated assessment, validity will override reliability. The problem is that as we look around the world at the assessments that command the most political attention and financial support, they are those of the first category. I have indicated elsewhere (Orpwood, 2007a) that I believe that this conflict poses serious threats to the future of this curriculum emphasis but that facing the threats requires both political and conceptual action.

DIMENSIONS OF TEST VALIDITY

"What counts as evidence of learning" is the key validity-related question that curriculum specialists and teachers are concerned about. As I have already noted above, this question is only now beginning to receive answers in relation to the second science curriculum revolution. Part of the reason for this is that for science education that incorporates socio-cultural and human values (SHV), or an emphasis on science, technology, society and the environment (STSE), the question resolves itself into three sub-questions:

- What counts as learning?
- What counts as evidence?
- Does this evidence of learning count for all stakeholders?

The first of these questions is necessary as the types of learning in curricula where SHV are integrated with Science and Technology are more complex than usual and require careful clarification before questions of evidence can be considered. Responding to these two questions constitutes the normal process of establishing the concept validity of an assessment. But my professional experience suggests that we need to add a third question that involves establishing the level of acceptance of the evidence of learning among the various stakeholders of the assessment.

Two Stories

I will illustrate these questions by reference to two stories, both true, one drawn from my own experience in developing science test items for TIMSS, and the other from the reports of colleagues in Alberta, Canada about the development of new science curriculum policy.

Developing TIMSS Assessment Items

During the early 1990s, as science coordinator of TIMSS, I worked with a science expert group, the national research coordinators (from participating countries), my opposite number in mathematics, and TIMSS technical and management colleagues to assemble the science portion of the TIMSS tests. A full account of this process appears in Orpwood & Garden (1998) but here I want to highlight the three broad criteria used to select items. We aimed for validity (basing our item selection on a blueprint developed from Schmidt's (1997) analysis of curricula of participating nations). Reliability was established through pretesting all items and the use of IRT scaling to obtain item characteristics and aid final item selection and test construction.

But, additionally, all items were scrutinized by the research coordinators from the 45 participating countries and, while no country had a veto over the inclusion of any given item, this review process was important as the tests were assembled. Many good items, especially those that touched on SHV or on links between science, technology and society were eliminated during this process. Some of these were dropped because of cultural sensitivities – for example, an item dealing with human reproduction was judged to be inappropriate by some Islamic countries. More often, however, the comment was made: "Our students would never be asked a question like that." Some countries were more particular than others about the items they wanted to see eliminated but I had no doubt that items incorporating societal values were among the most frequent casualties. The results of this process form part of the background to some of Peter Fensham's (2007) critical judgments about TIMSS, judgments with which I concur.

A few items in the Science Literacy component of the TIMSS tests addressed topics that included SHV but most were very conventional, calling for simple analysis of data about a scenario set in a social context. Only one question was of the variety where there was no one right answer – at least, no one answer was equally correct in all countries – and there was considerable resistance to its inclusion. It dealt with the social consequences of technological change and, not surprisingly, the results emerging from this item from across the participating countries proved fascinating to analyse (Bartley and Orpwood, 2005).

Developing Science Curriculum Policy in Alberta

My second illustration is from Canada, where the movement towards incorporating an STSE emphasis into science education – the second curriculum revolution noted earlier – was given significant boost by the publication of the Science Council of Canada's (1984) report on science in Canadian schools. The Canadian constitution designates education as the exclusive responsibility of the provinces and one of the first provinces to embrace this new direction was Alberta. In the late 1980s, the introduction of this emphasis into senior secondary school courses, with its inevitable incorporation of SHV, was attacked savagely by senior members of the science and engineering community with such phrases as "social science masquerading as science" and "dumbing down" of high school education (Byfield, 1989; Blades, 1994; Panwar & Hoddinott, 1995). After periods of "consultation" by a ministerial task force, the emphasis was softened significantly and the crisis averted. Fensham (1998) also reports Australian examples of where the STSE emphasis was "marginalized" as a result of criticism from influential members of the scientific community.

The power of the academic community cannot be underestimated in this regard. They control access to university science – determining which school-based credentials qualify a candidate for university admission. They also control the postsecondary scientific education of future science teachers – many of whom continue to hold such professors with high respect. Students aspiring to enter university, and teachers with responsibility for preparing them, disregard such pronouncements at their peril. The politics of academic approval are therefore likely to trump any efforts to incorporate an emphasis on STSE into the curriculum or assessment.

Summary: Two Dimensions of Validity

Figure 1 summarises the argument of the paper to this point. I am suggesting that there are two dimensions to the validity of assessments, the conceptual dimension, about which much has been written in the assessment literature, and the political dimension, which has been much less systematically studied.

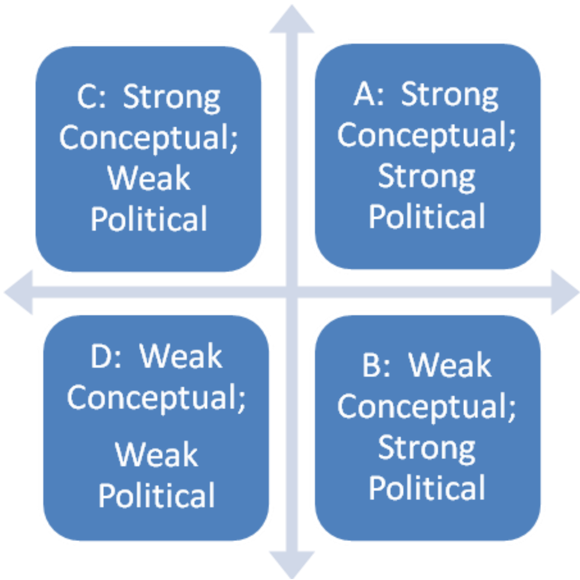

Figure 1. Conceptual and Political Dimensions of Validity

In an ideal world, the validity of assessments is both conceptually and politically strong (quadrant A). That is: We have identified the learnings we are trying to measure and the evidence for them, and, in addition, there is good support among the stakeholders of the assessment for both of these. Achieving a quadrant A assessment is the goal for all developers. Sadly, this goal is very hard to achieve as experience has shown.

Too easily, assessments can slide towards Quadrant B or C. Quadrant B represents those that are weak conceptually though strong politically: TIMSS is a good example, where the assessment may be a poor reflection of the aims of the curriculum in many countries but where it nonetheless commands strong political support among participating nations. Many national examination systems have failed to keep up with intended changes in direction in the curriculum and also fall in Quadrant B. In China, for example, new curricula have embraced an STSE emphasis and yet the examination system in some provinces has not kept pace with the intended change (Orpwood, 2007b). The result has been a significant drag on real curriculum change

Quadrant C represents the reverse problem – where an assessment matches the curriculum well but where only weak support among key stakeholders, notably members of the academic science community, has resulted in few students risking their future by taking courses whose assessments may have limited currency. The Alberta experience described above is an example. Quadrant D represents assessments that have neither strong conceptual nor political validity and is usually an empty quadrant.

AIMING FOR SUCCESS

Using the graphical device shown in Figure 1, we can consider what can easily happen with assessments that try to incorporate SHV. First, it is often hard – particularly in a formal assessment (as distinct from a teacher's informal classroom assessment) – to identify precisely those learnings that we want to measure and what would constitute good evidence for those learnings. Thus conceptual validity is difficult to achieve. Second, issues that touch on socio-cultural and human values are often controversial and thus their inclusion in an assessment can provoke criticism and resistance. These make political validity hard to achieve as well. Often the easiest response is one of retreat to the safe area of assessment of students' science knowledge.

Some curriculum and assessment initiatives have *not* retreated in this fashion and these give cause for optimism that the attainment of quadrant A for curricula and assessments, which integrate SHV into science and technology education is possible. The two examples described here illustrate two ways in which values have been integrated into science and technology education. They both have "official" status within their respective jurisdictions and therefore both have achieved at least a degree of political validity.

Science 30 in Alberta

The first example comes once again from the province of Alberta (Canada) though it is of more recent date than the story told earlier. Science 30 is a course taken by students in their final year of secondary school who do not intend to specialize in the more specific science disciplines at the postsecondary level. The curriculum handbook for parents makes its overall philosophy for science education clear:

> The aim of the senior high school science program is to help students attain the scientific awareness needed to be effective members of society (Alberta Education, 2009a).

This philosophy is further elaborated in the on-line program guide:

> … a science program must present science in a meaningful context – providing opportunities for students to explore the process of science, its applications and implications, and to examine related technological problems and issues. By doing so, students become aware of the role of science in responding to social and cultural change and in meeting needs for a sustainable environment, economy and society. (Alberta Education, 2007)

Further, the goals of the Science 20 and Science 30 courses include the following:

- Enable students to use science and technology to acquire new knowledge and solve problems so that they may improve the quality of their lives and the lives of others
- Prepare students to critically address science-related societal, economic, ethical and environmental issues.

It is interesting that, while at no point is the word "values" found in these documents, it is evident from the foregoing that the Science 30 course is intended that students grapple with highly value-laden socio-scientific issues.

Let us therefore turn to the assessment – at least the formal "diploma examination" set by Alberta Education – designed to assess students' attainment of these goals. The Science 30 examination is in two parts, a written paper and a machine-scored paper (Alberta Education, 2009b). The machine scored paper is divided into sections by topic and each section comprises multiple choice and numerical response questions in each topic area. The section on energy – of major importance and some controversy in Alberta as well as elsewhere – is fairly typical of the entire examination. The section is headed by the following statement:

> Space science may have an increasing role in shaping future societies, including the development of technologies to produce energy.

The section contains 14 questions on scientific topics related to energy, such as electromagnetic radiation, nuclear reactions, and energy conversions. Most of the questions are intended to elicit evidence of students' understanding of the science of energy itself and their ability to make appropriate calculations in this area. One multiple-choice question relates to environmental risk: it is headed by the statement: *"An environmental risk associated with burning coal is the production of acid rain"* and asks for evidence of students' knowledge about the effects of acid rain. Other sections of the examination, similarly *make reference* to issues of SHV but refrain from calling upon students to show evidence of their ability to deal with them.

The written paper, by contrast, calls for students to address the same range of topics but be able to develop conclusions and make arguments based on data provided in the paper and examine both sides of complex questions. For example, the first section provides data on vehicle emissions for cars and trucks using both petroleum diesel and biodiesel fuels. From this data, the students are asked to state one effect on either human health or the environment associated with a particular emission (this calls for some recall of what they had been taught but also the ability to make connections with the provided data). The paper goes on to ask the students to explain how the given data support the view that "biodiesel is an environmentally friendly fuel" *and* how the data contradict this view. In this way, the students are being assessed on their understanding of how science interacts with value-laden human, social, and political issues. Overall, therefore, the Alberta assessment lives up to its intended goals and demonstrates both conceptual and political validity (quadrant A in the chart above).

Twenty-First Century Science (UK)

I referred earlier to the 21st Century Science project, a British initiative of the University of York and the Nuffield Foundation. As was the case with the Alberta curriculum, the 21st Century Science web site speaks to its intention of fostering scientific literacy:

> The model offers all students the chance to develop the scientific literacy that they need to play a full part in a modern democratic society where science and technology play a key role in shaping our lives - as active and informed citizens.(21st Century Science, 2008) – Rationale

The overall program is quite complex with a variety of courses designed for students having differing career or postsecondary goals.

Information about the assessment takes the form of past examination papers which are available on the web site of OCR, the examination board associated with the project. Reviewing these examination papers suggests a very different approach than can be seen in the Alberta papers. The paper I reviewed was based on three short articles on socio-scientific topics, which the students had taken home to read and think about. Then the examination paper (which was also divided into three sections, each based on one article) had the students respond to a series of questions about each topic.

One topic for example was entitled "Is PVC safe for our children?" The preliminary article had concerned itself with the the uses of PVC, the use of plasticizers to change the properties of the PVC, scientific research on the effects of plasticizers, and the risks – particularly to children's health – associated with plasticizers. The questions followed a similar pattern and moved from early questions calling for evidence that the students had understood the article, and were familiar with scientific methods of investigation to later questions that addressed the more complex issues of risk and benefit. Here students were asked to think about the issues from more than one standpoint and to give evidence *for and against* a claim.

This assessment drew a clear line between matters on which there could be right (and wrong) answers and questions (such as the last one) where the values-laden issue was (politically and ethically) much less clear. The evidence being sought from the students was their ability to sort through complex issues and to consider more than one perspective. Both of these assessments, one from Canada and one from the UK also demonstrate that it is possible to assess the sorts of knowledge and abilities to be expected of an "active and informed citizen." Both clearly belong in quadrant A of the chart.

CONCLUDING COMMENTS

This paper has argued that in considering the assessment of science curricula that incorporate socio-cultural and human values (SHV), we must take into account both conceptual and political aspects of validity. This is very hard to do in practice and relatively few have been as successful as these two examples.

I have also tried to answer the question in my title: *Are SHV, science and technology, and assessment an impossible mix?* My response has to be a qualified "No"; not an impossible mix, but still quite a rare one and always one that is hard to achieve. This conclusion also suggests that two key lessons can be learned.

(1) If we wish to successfully implement a science curriculum rich in SHV, we cannot ignore assessment issues. To do so or to use traditional assessments almost guarantees that the SHV component of the curriculum will be reduced to a motivational frill and not the key emphasis;
(2) If we try create an assessment that is true to the spirit of an SHV-rich science curriculum, then we must take into account the political as well as the conceptual aspects of validity. Failure to do this risks that an otherwise good curriculum and assessment may be marginalized by the "powers that be" and ignored by teachers and students. Taking the politics of assessment into consideration and working hard to create a broadly acceptable assessment appears to be the only route to success.

While many educators are understandably nervous of politics and researchers of studying the politics of curriculum and assessment, we need more such studies if we are to learn lessons from their success and failure. Then we can become more adept at integrating SHV adequately into science and technology assessments.

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STUDENTS' DISCUSSION IN SUSTAINABLE DEVELOPMENT
- BASED ON THEIR OWN ECOLOGICAL FOOTPRINT

Katarina Ottander

Department of Science and Mathematics Education, Umeå University, Sweden

katarina.ottander@matnv.umu.se

Margareta Ekborg

Department of Science and Mathematics Education, Umeå University, Sweden

margareta.ekborg@matnv.umu.se

ABSTRACT

Within Education for Sustainable Development (ESD) various skills and knowledge are discussed, both in policy documents and in research reports. Therefore the aim of this study is to investigate what skills and knowledge students actually use in discussions related to sustainable development. Groups of students were observed when they worked with a task about Ecological footprints, within the subject *Science studies*. The subject is mandatory in all programmes in the upper secondary school and is about science for citizenship. Group discussions were audio recorded and transcribed.

A content analysis was performed and thereafter a specific search for utterances which could be interpreted as critical thinking, conflicts of interests or ability to use cause and consequences.

Results show that the students have ideas about “environmentally friendly behaviour” and shows interest in equity issues. There was some science in the discussions, for example food-chains and population growth. The skills critical thinking, cause and consequence reasoning and ability to see conflicts of interests were not frequently used.

The students were surprised and unaware of their own and Sweden’s ecological footprints. The most common conflicts of interests were between their lifestyle and environmental impact.

Keywords: *Science education, Education for Sustainable Development (ESD), classroom observation, Ecological footprints, upper secondary school*

INTRODUCTION

Sustainable development and education for sustainable development are abstract and complex concepts that societies and schools around the world are expected to work with. The World Commission on Environment and Development report *Our Common Future* (1987) is often referenced to when sustainable development shall be defined. Their definition is *"development which meets the needs of the present, without compromising the ability of future generations to meet their own needs".*

There are policy documents and reports that discuss the role of education within sustainable development. Learning is seen as an important part in the quest towards sustainability (Scott & Gough, 2003). Education for sustainable development should be based on an integrated approach to environmental, societal and economic development. The individual learner should have the knowledge, values and skills to be an active, democratic and responsible citizen (Baltic 21E). This raises questions about what knowledge and what skills are needed to become an active, democratic and responsible citizen. UN Decade of Education for Sustainable Development 2005-2014 provides the following six characteristics for ESD: Interdisciplinary and holistic learning, value based, critical thinking instead of memorizing, methodological pluralism, participation decision and locally relevant information (UNESCO 2009).

Sweden is unique in that all students have to attend a science course in the upper secondary school irrespective of what programme they choose. The Swedish curriculum for the upper secondary school (National Agency for Education 2000) states that this subject *Science studies* is an interdisciplinary subject in which scientific questions can be viewed from different perspectives. The aim is to provide scientific knowledge required to take a stand on issues that are important to the individual and the society, such as sustainable development and energy issues. The subject is about science education for citizenship and future profession.

Our research interest is science education for citizenship in the upper secondary school in *Science studies.* Science for citizenship is partly about developing people's ability to promote their opinion in socio-scientific issues. To do this they need knowledge *in* science and *about* science – nature of science. Both in science education research and in research about education for sustainable development there are discussions about how students develop knowledge, values and skills to be an active, democratic and responsible citizen. We want to bring these two areas together and study what will be learned when science education takes its starting point in sustainable development.

BACKGROUND

Today there is a consensus that science should be a compulsory school subject but the curriculum is mainly written by scientists who perceive school science as part of further studies in science (Osborne & Dillon, 2008). For a long time science education in school has been characterized by an academic tradition which emphasizes solid ground, the right answers, science structure and science skills (Swedish Research Council, 2005).

In literature review of the concept scientific literacy/science literacy, Roberts (2007) describes one vision about science education that is based on situations with a partially scientific content. Socio-scientific issues are scientific related situations that students may face as citizens, in which other considerations than pure science needs to be done. These issues can promote democratic citizenship through science education. Socio-scientific issues are relevant and can bridge school science and students´ lived experiences (Sadler, Barab & Scott, 2007).

The traditional, science-oriented approach to environmental education has been criticized for leading to knowledge about the existence of environmental problems but not leading to action competence. It has not been capable of addressing the social and societal perspectives of these questions (Jensen & Schnack, 1997). Many of the political and moral problems confronting society today are posed by the advance of science and technology. Osborn and Dillon (2008) discuss that these dilemmas require a solution which involves a combination of assessment of risk and uncertainty, a consideration of the economic benefits and values, and some strengths and limits of science. To understand the role of science in such dilemmas students need to be educated to become critical consumers of scientific knowledge.

The Swedish National Agency for Education also finds that the three-dimensional definition of sustainable development by integrating economic, social and environmental factors has not yet been implemented in the Swedish education (SOU 2004:104).

According to the syllabus for *Science studies*, students shall learn science in contexts of socio-scientific issues such as sustainable development. It seems as though topics with social relevance are more motivating for the students. On the other hand, they are often complex, and therefore more difficult to understand (Aikenhead, 2006). Research has revealed that such issues challenge students' rational, social and emotional skills. However, several problematic factors are identified, such as that the students can easily be distracted when they are working with multifaceted issues where the outcome is often not clear (Zeidler, Sadler, Simmons & Howes, 2005). This means that there might be a conflict between the dilemma-based issues' potential for motivating students and for making them focus on the scientific content.

Critical thinking and ability to see complexity are important skills in ESD. Critical thinking is described as reflective and evaluative thinking which necessarily leads to substantiated judgements (Mogensen, 1997). He argues that in the democratic perspective it is important to become a critical thinker. To question critically, and act according to the answers founded, is contributing to the development of a more democratic and sustainable society.

Many different areas of knowledge are involved in ESD and the issues are often value based and have an ethical dimension. Such issues often include conflicts of interest between individuals or groups of people (Jensen & Schnack, 1997; Lundegård, 2007). To be able to identify conflicts of interest and to use the cause and consequence thinking can be seen as some criteria for complex reasoning (Ekborg, 2005).

Environmental and development issues are taught in different ways in schools. A study in Sweden identified three different selective traditions within environmental education. These are the *fact-based* tradition, the *normative* tradition and the *pluralistic* tradition (Östman, 2003). In the fact-based tradition, environmental issues are treated as problems that can be solved by more knowledge. In the normative tradition, the aim of the education is to support an environmentally friendly transformation of society. The pluralistic approach is characterized by a striving to promote different perspectives and values when dealing with problems concerning the future world (Öhman, 2008). About half of the teachers in Sweden are teaching in sustainable development in accordance with the normative tradition (Östman, 2003). There have also been critical discussions about education *for* sustainable development, that it will lead to indoctrination and that the students will not learn skills to think for themselves (Jickling, 1992).

AIM

The aim of this study is to investigate what skills and knowledge students actually use in discussions related to sustainable development. We used the example of Ecological footprints. Our special focus is on the science content.

The research questions are:
What do the students talk about in a discussion about Ecological footprints?
What kind of conflicts of interests do the students bring up in discussions about Ecological footprints?
Do the students use causes and consequences and apply critical thinking in their discussions?

RESEARCH DESIGN AND METHODOLOGY

This is an exploratory study in the sense that the research questions are open and there is a need to learn from the participants in the study (Creswell, 2005). The students were observed when they worked in groups with a task about Ecological footprints. The group discussions were audio recorded and transcribed verbatim. We have followed the Swedish Research Council's ethical rules (Codex n.d.).

Participants

The study has been performed in an upper secondary school in a town in northern Sweden. The students were in their first year and attended the course *Science studies*. Before this study started the students had studied ecology and energy and we came in when the content about sustainable development was to be introduced. The 24 students, 4 male and 20 female – attended two programmes: a social science programme and a programme to become hairdressers.

Education purpose and design

We followed the class during the first two lessons related to sustainable development. The purpose of the two lessons was to create interest and to make connections between students lived lives and sustainable development. It also gave the students the opportunity to see the complexity in these issues and be aware of the global dimensions. The Ecological footprint is a measure of the demand human activity puts on the biosphere. It measures the amount of biologically productive land and water area required to produce all the resources an individual, population, or activity consumes, and to absorb the waste they generate, given prevailing technology and resource management practices (so called global hectares) (Ewing et al., 2008). To understand the concept you need science and it becomes obvious that these issues are global.

During the first lesson students, in pairs, calculated their own Ecological footprint. The students used the WWF website (2009) to convert their consumption and waste-production within four categories, food, home, transport and waste into global hectares. During the second lesson the students discussed their results in small groups. There were six groups of four students each.

The design of the small group discussions were that the students were given the opportunity to have an open discussion about thoughts that the footprint calculation lesson created. When the spontaneous discussions ended they were given some questions and claims to discuss, like;

- Globally we use resources corresponding to 1,4 planets, how can that be possible?
- Some countries Ecological footprints per capita.
- Meat- and paper consumption for the richest 20% of the population on earth.

Data analysis

The analysis is based on the group discussions from the second lesson. A content analysis was performed (Bergström & Boreus, 2005). The content of the discussions was categorized into different categories. After several readings we found the following categories, the three dimensions of sustainable development –ecological, social and economical dimension. In the social dimension politics, equity issues, health and working conditions were included. We also found the categories environmentally friendly behaviour and personal experiences.
A specific search for utterances which could be interpreted as conflicts of interests, ability to use cause and consequence reasoning and critical thinking was also performed. When students put two interests against each other we have taken that as a conflict of interests. Both if students have shown awareness about the conflicts on a structural level for example between economy and environment and conflicts on an individual level were identified. Within the individual level we included both when students expressed that their lifestyle was

threatened and conflicts between different groups of individuals. When students have reflected, evaluated or asked questions about a statement we have taken that as indicators of critical thinking

RESULTS

Overall the discussions are moving from food, transports, energy use and waste- production when the students present their results. The students relate to “environmentally friendly behaviour” which they have ideas about. It was also the most common content of the discussions. When we look at the three different dimensions that often are used when we describe sustainable development; ecological, economical and social dimension we can see that all dimensions are discussed more or less in different groups. Personal experiences were also discussed (table 1).

Table 1. Content of the group discussions. Y means that it was in the discussion three times or more, ¤ twice or less, - means that it was not in the discussions.

Content / Group number	Ecology/ Science	Economy	Social			Environmentally friendly behaviour	Personal experience
			Equity	Politics	Other		
1	Y	Y ¤	-	Y ¤	Y ¤	Y	-
2	-	Y	Y	Y	Y ¤	Y	Y
3	Y	-	Y	Y ¤	-	Y	-
4	Y	Y ¤	Y	-	Y ¤	Y	Y
5	Y	-	Y ¤	-	-	Y	Y ¤
6	Y ¤	-	Y ¤	-	-	Y	Y ¤

In four groups the students were unaware of their own and/or Sweden’s big ecological footprints and were surprised when they found out. The students showed interest in equity issues in five out of six groups (social dimension).

The most common science content that was discussed was about food-chains, food-webs and population growth. Other comments were about physiology, natural selection and matter flows. The students used science as statements to tell what nature is like, e.g. that nature is trying to keep things in balance. They did not use science or scientific skills as a way to make progress in the discussions or create understanding about science issues. For example when they got information that we use resources corresponding to 1,4 globes, they did not use their knowledge about different natural resources to find out how or if that could be possible.

The most common content in the discussions was “environmentally friendly behaviour”. Below is an example of a discussion about this in one of the groups:

Sofia: - *It would be good if everybody recycle their waste.*
Gun: - *Buy ecological stuff.*

Helen: - *Stop going by car*
Sofia: - *Walk or take the bus*

To see the complexity in the discussions, we searched for the above mentioned conflicts of interest (table 2). The most common identified conflicts of interest were between their lifestyle and environmental impact (see excerpt below) and economy and environment. Conflicts of interest between different groups of people and between animals and humans were only mentioned twice each.

Erika: - *ehh, we could live on what we really need*
Tina: - *not like this...all the unnecessary stuff and so*
Jens: - *how boring life would be*

Another way to see complexity is the use of cause and consequence reasoning (table 2). Most common was how economy influences human behaviour and how human population growth will affect the environment. Other examples were about how society creates opportunities for people to live "environmentally friendly", for example makes it easy to go by bus or create opportunities to sort their garbage. Overall cause and consequence reasoning was not a skill used very often.

In the discussion with Sara, Tina and Anita (group 4) there are examples of critical thinking. This skill was used in three groups but not very often (table 2).

Sara: - *but look, if we live at 1, 4 (globes), we still live at one (globe)*
Tina: - *Yes, everything is still..*
Sara: - *Who has calculated this, I wonder.*
Tina: - *Yes*
Sara: - *We still have enough food*
Tina: - *Yes, all*
Sara: - *Don't we? There is still a lot of food.*
Anita: - *Maybe Elise's grandchildren can't have any food.*
Tina: - *Yes but what, these poor. They have to get it better. It would be better if it was more equal so that*
Everybody starts talking
Sara: - *We have to climb down and they have to get up*
Tina: - *Yes, exactly*
Sara: - *Yes but what, it is still the same result.*
Tina: - *Yes but*
Sara: - *They can't mean that we all shall live as*
Silence

Table 2. Skills used in the group discussions. Y means that it was in the discussion three times or more, ¤ two times or less, - means that it was not in the discussions.

Skill	critical thinking	cause and consequence	conflicts of interests				
			lifestyle - environment	economy - environment	humans - humans	humans - animal	other
1	-	Y	Y	-	-	Y ¤	-
2	Y ¤	Y	Y ¤	Y	Y ¤	-	Y ¤
3	Y ¤	Y ¤	-	-	-	-	-
4	Y	Y	Y ¤	Y ¤	-	-	-
5	-	-	-	-	-	Y ¤	-
6	-	Y ¤	Y ¤	-	-	-	-

DISCUSSION

The task with calculating their own Ecological footprint and then discussing the results created opportunities for the students to integrate the social, economic and ecological dimension in sustainable development. In the discussions, students focused on environmentally friendly behaviour. When they found out about the equity issues in this task, the interest increased and those issues were discussed. The ecological/science dimension was not discussed much and it was not in a reflective way. The question is whether the students learned any science. At least they never discussed and asked questions about the science content. This study indicates that when sustainable development issues are learned in school, the ethical dimension creates most interest. The conclusion that Aikenhead (2006) discussed that topics with social relevance are motivating for the students but also are complex and therefore more difficult to understand is also indicated in this study. In science education we have a challenge in inquiry based teaching about sustainable development, to create tasks where the students can integrate the different dimensions but also focus on and learn science.

The students demonstrated knowledge about environmentally friendly behaviour. The different behaviours were not questioned during the discussions. In the discussions there is a consensus about “a good behaviour”. The results of this study indicate that in this school situation the students thought that they should relate to “environmentally friendly behaviour” and did not use skills as critical thinking, cause and consequence reasoning and identified conflicts of interests that much. If it is the normative teaching tradition in environmental education that causes this is impossible to say. These issues are often discussed in a normative way in school (Östman, 2003) but also in media. It shows that it is important how we construct tasks and that the classroom discourse encourages critical thinking.

According to curriculum and policy documents we shall teach and learn for sustainable development. This study indicates that in these issues we have to plan very carefully so that the teaching encourage critical thinking and not only teach the students norms surrounding it. We also have to give the students opportunities to find out and learn about conflicts of interests on a structural and societal level and not only on the individual level.

Future direction

It is interesting how complex issues within sustainable development affect the learning. Do students manage to learn both about the complexity between the different dimensions and learn science in sustainable development issues? Is the ethical dimension so interesting so that it overshadows the other dimensions or does it enhance learning? How students use and learn skills as critical thinking to make progress in their learning is also important to know more about. This will be studied further.

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ACCESSING CULTURAL HERITAGE THROUGH A HISTORY AND PHILOSOPHY IN SCIENCE TEACHING (HIPST) PROJECT ON TEMPERATURE

John Oversby

University of Reading, UK

ABSTRACT

Promotion of engagement with science learning at the adolescent stage is a major challenge for science educators. The European History and Philosophy in Science Teaching Project has focused on providing resources for supporting historical and philosophical approaches. This paper describes the theoretical underpinning for a project on measurement of temperature for 11 year old students in UK schools. The topic lends itself to a phenomenological approach suitable for novice learners in school, and avoids the more advanced thermodynamic treatment that would be beyond these students, while maintaining elements of rigour. Development of the module involved close collaboration between the researcher and two of the teachers, through discussion of the lessons, and subsequent feedback and reflection on the evidence collected. Data collected suggests that the teachers made substantial progress in their understanding of the place of History and Philosophy of Science in science teaching, partly through the innovative methods employed in the class of student newspapers and student play scripts. The students were hampered in their progress by problems in providing appropriate laboratory equipment and by poor literacy for some of them. Nevertheless, significant progress was made by a majority in understanding principles of measurement in the context of temperature. An associated wiki (a web-site that allows easy creation and editing of inter-linked pages using a simple web browser) was created and had some modest use by the project participants.

Keywords: *History, philosophy, temperature, engagement*

INTRODUCTION AND BACKGROUND

The 30 month, 8 country, EU History and Philosophy in Science Teaching (HIPST) project was established in February 2008. The UK part of the project has focused on three themes. The themes were: a) the role of creating measuring instruments in concept construction using the topic of temperature; b) creating an idealized concept from real and imperfect instances, using the topic of acidity; c) the special place of modeling in chemistry through paper tools, using the topics of chemical formulae and chemical equations. The theme described in this paper is Measurement in the context of temperature. Temperature was chosen because, in England, it is a traditional part of the National Curriculum at this age, and because it relates well to particle ideas of matter. Under Cultural Understanding, the same National Curriculum requires pupils to 'recognise that modern science has its roots in many different societies and cultures, and draws on a variety of valid approaches to scientific practice'. The science education community's values are embedded, often implicitly, in its intended curricula. For example, the Science National Curriculum in England for 11 – 14 year olds (QCDA, 2009) states that: 'Pupils learn how knowledge and understanding in science are rooted in evidence. They discover how scientific ideas contribute to technological change – affecting industry, business and medicine and improving quality of life. They trace the development of science worldwide and recognise its cultural significance.' Similar statements are made in the curricula of other countries. The American Association for Advancement of Science (Project 2061) (AAAS, 1993, 2009) notes: 'The images that many people have of science and how it works are often distorted. The myths and stereotypes that young people have about science are not dispelled when science teaching focuses narrowly on the laws, concepts, and theories of science. Hence, the study of science as a way of knowing needs to be made explicit in the curriculum,' with development of some of the history to exemplify what should be done. Evidence from the ROSE (nd) project suggests that learners value human aspects of science.

THE HIPST PROJECT

HIPST presents an effort by science education scholars to promote science education by the development of materials for teaching and learning science which are informed by the history and philosophy of science (HPS).' (Höttecke, 2008) The project members agreed that the place of History and Philosophy of science in schools was both extremely under-represented and presented in a dry fashion, contributing to disengagement with school science. Their understanding of the ROSE (n.d.) evidence was that school science, in western countries at least, was devoid of humanity. Research (e.g. Williams, 2002) indicated that history of science was presented in textbooks in the form of 'heroes and villains' with little indication of the human side of the scientists other than that they were born and died, and discovered something important in their lives. These discoveries were rarely set in the context of the international community of scientists working at the time, or of their discussions and access to particular pieces of equipment. There was little recognition that many worked on their own, sponsored by rich aristocrats or by industrial philanthropists, or were themselves wealthy. Others worked in institutional laboratories, in universities that were creating departments of research and teaching in the sciences, with a coterie of colleagues benefiting from their academic research leadership. Indeed, there is little evidence in textbooks that the scientists had working lives full of frustration and excitement, who met from time to time, sometimes in fledgling learned scientific societies. In short, the historical depiction in scientific textbooks can be described as sterile, and usually brief.

Rather more worryingly, the philosophical base in textbooks is almost non-existent, being relegated to short discussions of a fairly naïve view of the nature of science that claims there is one scientific method.

I have devoted some time to material in textbooks since these appear to be a major resource for teachers in learning about appropriate pedagogy. An absence of space devoted to HPS in textbooks would suggest a similar position in practical teaching.

The HIPST project members are convinced, in the first place, that inclusion of the History of Science in everyday teaching is necessary as part of the process of humanizing science. They are also aware that published scientific papers are reductions of the scientific process that omit dead-end thinking, alternative ideas that were conceived and then discarded after discussion and review, and challenges in apparatus construction and measurement. It seems that textbooks take this a step further and largely restrict their content to well-established content and ways of thinking. So, their second aim was to provide resources that would provide a more authentic view of how science progressed in the past, using historical narrative resources such as biographies and autobiographies, and contemporary accounts of the stories of ideas construction. This might include replicating historical scientific experiments. Their third aim was to use historical data, or data from replicate experiments, to recreate the scientific discoveries, and to notice the challenges that faced the original researchers. In this way, not least because the data collection and analysis problems have already been recorded in the historical literature, they can more easily support the learners in understanding how science works from the past. The HIPST project members were strongly aware of the challenge of making judgments of past scientific work from the perspective of our present knowledge. This is known as whiggishness. Their fourth aim was to avoid this trap in producing and trialling materials. The fifth aim was to develop teachers' views about the nature of science, perhaps through discussion of the trial materials, since teachers' personal subject knowledge is a great influence on teaching and learning in the classroom. The evidence available to the HIPST project suggested that historical examples can provide clearer learning about the nature of science than more contemporary examples. Finally, the sixth aim was to develop pupils' views about the nature of science through these examples.

The particular specialism of the UK part of HIPST was that it was mainly focused on chemistry, and on learners aged between 11 and 14 for two of the themes. At this stage, learning of the sciences tends to be largely phenomenological and descriptive, especially in chemistry. The focus of other HISPT projects in the other countries was mainly directed towards older learning, with many programmes in quantitative physics. HIPST in the UK offered an opportunity to tackle the challenge of engaging younger learners with HPS materials. Historical background material in sciences tends to be more obviously related to older learners, so a major question was whether there was a suitable topic for those in the 11 14 age range. This topic had to be related to the existing curriculum.

The topic of temperature is one such topic. The history of the concept of temperature is well documented (e.g. Chang, 2004) and there are many web sites devoted to this history. Unusually among measurements, temperature is independent of the three base units, mass, distance and time. Chang (2004) convinces us that devising methods of measuring temperature helped scientists in the past to clarify their understanding of the concept. This phenomenological approach makes it amenable as a topic for young learners, particularly as a route for introducing the philosophy of measurement. Issues such as standardization, calibration, sensitivity, and accuracy are central to temperature measurement. I faced the choice of where to stop the study. Fortunately, the absence of a direct link with the three base units makes the issue of absolute temperature measurement a distinct break from the phenomenological approach. Absolute temperature is only precisely defined in terms of an ideal gas, and that makes it inaccessible to these young learners.

This work is also concerned with the teachers as learners. The matter of personal subject knowledge for science teachers is complex. The teachers involved in this work declared their limited prior knowledge of specific historical knowledge, and their even more limited prior knowledge of specific philosophy of science. Therefore, this work was intended to improve both those aspects of the teachers' knowledge.

METHODS

Research questions

1. What are the purposes of including History and Philosophy of Science (HPS) in school curricula? What HPS is embedded in curricula?

2. What is presently known about the effect of HPS teaching in schools?

3. How do teachers respond to an explicit HPS teaching programme?

4. How do young learners respond to an explicit HPS teaching programme?

1 and 2: These were mainly desk studies supplemented by meetings with teachers.

3: Three teachers undertook to teach a module on temperature to explore the effect of measuring on validating, and developing the reliability and accuracy of scientific equipment. The teachers took part in discussions by email, face to face conversations that were recorded by hand, and one by constructing a reflection log

4: Teachers in two schools volunteered to trial materials with a total of 150 pupils aged 11-12 years old. Data collection included open-ended written questions, recording of learning in notebooks, field observations by the author, debriefing discussions by the author that include reports agreed with the teachers, pupil play scripts about a historical event. In each of the lessons, the teachers planned small interventions by the researcher (co-teaching) to demonstrate some aspects of teaching this innovative material. These requested interventions amounted to 5 or so minutes in each of the lessons. As the project developed, the researcher produced one or two page newspapers for the pupils, incorporating historical evidence, anonymised pupil conversations, and some optional puzzles for the pupils to carry out in their own time. The newspapers also incorporated specially produced short play scripts to explain historical events. The researcher also produced staff newspapers to summarise training sessions and to share with other science colleagues.

DESCRIPTION OF THE EXPERIMENTAL MODULE

The following table focuses on the outcomes after trialling and evaluation over two cycles. Underlined text indicates modifications after the trials.

Table 1. Description of module on temperature

Lesson outline	Learning objectives	Teacher guidance	Assessment opportunities
1. a) Weber's Three Bowls activity b) Introduction to liquid in glass thermometer as a practical method of determining temperature c) Exploring determination of upper fixed point. Thermometer placed at various points above and in boiling water. Accept liquid in glass thermometer and explore issue of where and how to measure the upper fixed point. Focus on need for measurement.	a) Critical evaluation of skin as thermometer. Folklore of everyday measuring temperature e.g. elbow in bath water for young children. Need for more reliable method. b) Explore issues of where to measure the upper fixed point, and the need to specify standard conditions. Specifying conditions in using measuring equipment is part of improving validity, reliability and accuracy. c) Understanding the meaning of thermometric property, in the context of a liquid in glass thermometer. d) At a higher level, to understand that the thermometric property may not measure temperature, but we accept that it is the best we can have.	a) Weber's experiment is traditional. Here the emphasis is on the need for carefully specified standards in providing for high quality equipment. Using the human body is simply unreliable in determining temperature. b) In the first trial, the 11 year old pupils were very clear that the boiling point of water was 100ºC, not least because that was what they had been told at Primary School. This activity will fail if all it does is to say, for example, place the thermometer at point x, because that was where it read 100ºC. It might be easier for pupils to appreciate if they were asked to put themselves in Celsius' place, and a bit of history from the teacher may be helpful here.	a) Diagram sketch with thought bubbles to give pupil thinking (e.g. feels hot/cold in the middle bowl!). Use of standard and reliability in account to show explanation of the underlined terms. Diagram sketch with annotated temperatures at different levels. Include a written discussion to show pupil thinking to indicate explanation of standardisation/ calibration, in measurement, and idea of specified conditions to ensure reliability focusing on underlined words. The scientific ideas here are measurement (see paper in wiki), reliability. These are fundamental to processes of collecting scientific data. Write a clear set of instructions to specify the exact conditions.
2. Exploration of the gas thermometer as the most valid and reliable practical thermometer. a) Pressure increases when a gas is warmed up. Explain in terms of particles moving faster and hitting the walls more often. With finger over the end, dip a syringe half full of air in a bowl of warm water and feel the pressure. b) Measuring the pressure. Use a giant water (coloured) manometer (arms at least 2 m long), and a boiling tube fitted with stopper and connecting tube. The	a) Understanding meanings of validity, reliability and accuracy through focusing on historical approaches to determination of a practical thermometer. Applying particle knowledge to effect of temperature on pressure of a gas. This is known as Gay-Lussac's Law: Gay-Lussac's other law, discovered in 1802, states that: *The pressure of a fixed mass and fixed volume of a gas is directly proportional to the gas's temperature.* From http://en.wikipedia.org/wiki/Gay-Lussac's_Law	The issue with liquid in glass thermometers is the uneven expansion of both the liquid and the glass with temperature (although how that was determined is another story!) In practice, for mercury thermometers, the uneven expansion of the glass compensates quite well for the uneven expansion of the mercury, quite fortuitous. It was the search for a uniformly variable thermometric material that led scientists to the constant volume gas thermometer. The constant volume gas thermometer turned out to be the most valid, reliable	a) An annotated sketch (bubbles) of a syringe in warm water with particles moving, to explain increase in pressure. An annotated particle picture of a manometer to show how it indicates pressure An annotated diagram to show how different levels relate to the ice point and steam point in a manometer. An annotated diagram with calibration marks to show how the scale is constructed. Explain the meaning of accuracy, reliability and validity (this last one will be very hard) in the context of the gas thermometer.

water in the manometer arms should be half way up to start. Cool the open boiling tube in ice water to let the temperature settle. Connect gently to manometer. The levels should be the same on both sides. This is the ice point calibration level. Now warm the boiling tube with hands and watch the levels change. Discuss in terms if faster moving particles increasing the pressure. Now place boiling tube in boiling water (steam point) and mark upper fixed point. Finally, place boiling tube in hands and estimate the temperature from the levels. Discuss how to calculate and the notion of a scale. c) Estimate the temperature to reach 12 m (one atmosphere). d) Discuss the idea of negative temperature in terms of water levels. e) Estimate the temperature (negative) to reach zero pressure (boiling pint tube higher) i.e. absolute zero.	b) Understanding the meaning of thermometric property, in the context of a gas thermometer, i.e. pressure. c) To know about the efforts scientists made to reduce errors (to improve both accuracy and reliability). This includes reducing the volume of air at an unknown temperature (short and narrow tube), and to measure the temperature of the air in this tube to allow for it. d) To be able to use the gas thermometer to detect different temperatures. e) To be able to calibrate the gas thermometer at the ice point and stem point (if possible) f) To be able to determine an intermediate temperature by interpolation. g) To be able to extrapolate to absolute zero.	and accurate practical thermometer available. In practice, the air should be dried, and mercury would be used for the manometer to avoid water vapour. Additionally, since we are interested in the temperature of the air in the container, the connecting tubes would be kept as short as possible, and as narrow as possible to minimise the volume of air at a different temperature. A correction for this external volume would be made, using a mercury-in-glass thermometer for its temperature as being good enough. It is, after all, only a small correction! The gas thermometer is likely to be a new piece of equipment for many teachers. I have provided some pictures of various types below *(in original text*). The thermometric property is the pressure of the gas.	b) Explain the meanings of interpolation and extrapolation.
3. Reflection corner. The purpose of this activity is to promote some reflections by the pupils into historical scientific progress concerning temperature. We are using pupil plays to share first ideas about the problems of standardising. These plays can be prepared in advance and then shared in small groups. The debate can be recorded by two pupil scribes, to provide a record of the discussion. The group could be self-monitoring, rather than having a chair.	a) To be able to give reasons for standardising in measurement, such as improving validity, reliability and accuracy. b) To be able to recount, in modern terms, historical efforts to standardise measuring temperature. c) To be able to reflect on the role of scientists in determining temperature.	Formative assessment of reflection is a challenge in this section. Firstly, there is experimental work to be done on using plays for assessment purposes. This is rather innovative! Secondly, there is the use of debate to put forward claims, to examine evidence and to come to conclusions. This is not new, and is part of argumentation, but it has not been based on written plays before.	a) Short play to recount problems of fixing the steam point. b) Debate to check pupil understanding of process of standardizing. c) Evidence to show understanding of validity, reliability and accuracy developments in science.

RESULTS

Research question 1: What are the purposes of including History and Philosophy of Science (HPS) in school curricula? What HPS is embedded in curricula?

Williams (2002) surveyed the history of science in textbooks in England in 1999, following the integration of history and philosophy of science into the mainstream school science curriculum. He notes that, history of science is often relegated to brief and sterile 'heroes and villains' descriptions.

Pedagogical innovations that have engaged most pupils have included producing play scripts of scientific stories, and newspapers written in simple language. Using pupil work as a source of material for newspapers has also been an important innovation. The pupil newspapers have also served as a valuable source of information for the teachers. Some new activities have been developed: lack of equipment in schools and skills of technicians was a barrier, and has led to specific training for the latter. The project has noted that underlying understanding of basic concepts, such as particle ideas, needs to be secure for the full potential to be achieved. Many pupils have produced extra work, and focused on working with the new pedagogy.

Höttecke (2009) in his ESERA paper acknowledged the importance of History and Philosophy of Science towards school teaching, and the dearth of research about HPS teaching in schools. He also reported the lack of curriculum resources for HPS teaching in schools.

Under Cultural Understanding, the National Curriculum in England requires pupils to 'recognise that modern science has its roots in many different societies and cultures, and draws on a variety of valid approaches to scientific practice' The same national Curriculum goes on to say that pupils in lower secondary schools should 'explore contemporary and historical scientific developments and how they have been communicated'. The National Curriculum does not prescribe how this should be carried out. HPS is implicit in the model of How Science Works, since historical data can provide valuable experience for learners to analyse and interpret. Historical data also provides alternative interpretations for learners to critique as part f learning how to evaluate data they collect themselves in investigations.

HIPST has accepted a range of purposes for HPS teaching in schools. These are documented on the HIPST web site and a brief reference to them is given here. The original paper contains details of the references.

'Contextualized Learning: Curriculum developers all over Europe have stressed the role of **context for science learning**. From a student perspective a context enriches science learning with meaning and shows how science is inextricable merged with society, economy, ecology and culture. Therefore, historical reflections of the role and character of science are not restricted to perspectives on the past, but contribute to an **understanding of the interaction of science and society** in general.

Advancement of problem solving skills: International comparative studies like PISA have shown that competences of **problem solving** are deficient in many European countries. History and philosophy of science highlight the process of science in a rich cultural context and open up ways to science teaching and learning which is jointly oriented to the process of science as well as to the process of learning. The history of science is full of opportunities to study the problem solving activity of real scientists in authentic situations.

Inquiry learning within historical settings: Inquiry learning fosters the learning of scientific concepts. Inquiry learning encourages students to develop their own **strategies of problem solving**. The history of science provides a wide range of resources for inquiry learning in this sense.

Reconstruction of historical experiments: If students work with reconstructions of historical experiments they will be engaged with authentic problems, build small scientific communities, which share their knowledge and skills or demarcate themselves from those of other student-communities.

Promotion of a better comprehension of scientific concepts: This argument recognizes that **scientific concepts** can be formulated more intelligibly in their historical context of discovery than in a schematic and systematised way of modern interpretations.

Supporting conceptual growth: Research indicates that the study of **historical concepts can help students to develop their own concepts towards a scientific comprehension**.

Showing science as European cultural heritage: Students become aware of the **different national contributions to science**.

Learning about the nature of science: In a Delphi study (Osborne *et al*., 2003) have shown experts of science education, science, history, philosophy, and sociology of science to generally agree that **learning about the nature of science** belongs to the central objectives of science education.

Explicit reflection on the nature of science: Research has shown that even inquiry-oriented teaching does not necessarily lead to a better comprehension of the nature of science. Several studies recommend **explicit reflection on the nature of science** which is an integral part of teaching the history and philosophy of science in our view.

Developing citizenship in a science and knowledge society: The nature-of-science-argument promotes the view that **active citizenship in democratic decision-making processes** requires knowledge about what science means as political decision-making increasingly depends on scientific expertise.

History as a tool for teaching about the nature of science: Several studies indicate that epistemological beliefs about knowledge and knowledge acquisition affect attitudes and processes of learning. Research and case studies of teaching practice have shown the **effectiveness of history-oriented teaching** in order to learn about the nature of science.

Science as a human endeavour: Science appears less abstract and gets the **character of a human endeavour**. This argument touches the problem of public recognition of science as systematic and inhuman.

Supporting authentic images of science and scientists: The inclusion of historical case studies in science teaching provides realistic **images of science** as process and **images of scientists** themselves.

Promoting girls' attitudes towards science: Research indicates that especially **female students benefit** from the changing character of science as an open inquiry and from the appearance of scientific knowledge as progressive and changeable.'

Research question 2: What is presently known about the effect of HPS teaching in schools?

This has been answered in the response to research question 1.

Research question 3: How do teachers respond to an explicit HPS teaching programme?

The draft activities were produced by a working group composed of the HE researcher and a group of 6 teachers over a period of 6 months. The working group met four times and communicated by email in the intervening time. The draft activities were then subject to trials, over a three week period in two schools with three teachers. As each teacher trialled the materials in lessons, the material was modified and the modified materials, with the justification, passed to the next teacher. In this way, a three cycle development programme took place.

One teacher took part in a structured interview after the teaching trial that was recorded in the form of brief notes. A second teacher wrote a similar report based on the same questions. One teacher was a specialist in chemistry and the other in physics. They were in different schools in the same local authority. Both teachers mentioned their initial interest in the project as part of their professional development. Neither teacher had studied philosophy of science prior to the project. Both teachers had a very modest knowledge of some historical material. Each trial was initiated by three training sessions, one to one with each teacher, each lasting one hour. During these training sessions the purposes and details of the activities were discussed, and often led to further modification of the lesson plans. Each session was subject to a face to face debriefing of between 30 and 60 minutes immediately following the lesson, with notes made and discussed by the researcher with the teacher. Further discussion took place by email and by telephone. An associated multi-layered wiki (a web-site that allows easy creation and editing of inter-linked pages using a simple web browser) was created and had some modest use by the project participants. The wiki is at www.ukhipstinstruments.wikispaces.com.

The first teacher reported some modest misunderstanding in the purpose of the activities despite the training sessions. On reflection, this may have been caused by the teacher and researcher providing insufficient time for discussion of that aspect in the training. Perhaps it was assumed it was obvious after only a short discussion time. Both teachers mentioned the successful outcome of the Three Bowls activity, which they had done before. The activity in determining the steam point in boiling water was mentioned as one that was carried out reasonably, but they felt was not as successful in learning as they would have liked, partly because they had not focused on the issue of measuring temperature, as just reported. Both teachers mentioned the gas thermometers with manometers. This lesson had proved to be problematic in terms of equipment. There were only one or two Bourdon pressure gauges in each school. The teachers had expected there to be a few more from their own knowledge but were surprised by how few there were when they asked the technicians. They believed there would be enough for one for each of four groups. The project group also chose to use water manometers for determining pressure (mercury manometers are forbidden on safety grounds, and this was known in advance). The water manometers had to be 2 m long in order to accommodate the changes in pressure in going from 0ºC to 100ºC. Construction of such manometers was new to the laboratory technicians and the final solution in each case was, probably, unsatisfactory, especially in the light of their limited materials to work with. Both teachers reported some difficulties in making sense of the philosophical purposes of the activities, and, therefore, in promoting the learning of the pupils in that respect, even though this had been thoroughly discussed in advance. The teachers appreciated the newspapers written for the pupils as learning tools for themselves. They both indicated very strongly a willingness to go for another trial the following year.

Research question 4: How do young learners respond to an explicit HPS teaching programme?

As expected, the young learners were tolerant towards the lessons as judged by their behaviour and questions. Their class notes and discussions indicated strong engagement with the activities, not least in attempting to measure the boiling temperature of water when they were not quite sure about the historical problems in doing this. In the second trial, many of the pupils were seen reading some of the newspapers, although the teacher commented that the language may have been challenging for many. They were impressed by the story of Gmelin's 1830 expedition across Siberia at the behest of Catherine the Great. Some of them took part in an optional activity to produce a play script to show their understanding. The play scripts produced by some of them showed that they understood that the issue was the problem of the mercury freezing in determining the lowest temperature reached using a mercury thermometer. They were aware that solid and liquid mercury could shrink at different rates. There was some extra effort put in by some pupils in producing play scripts, as well as in conducting surveys at home about the meaning of temperature. This is an indication that the pedagogy used in this project strongly engaged these pupils, not least because the teachers reported that the pupils rarely undertook extra work of any kind.

CONCLUSIONS AND IMPLICATIONS

The materials produced for the first theme have been trialled and reviewed. The results so far have established the strength of a collaborative two cycle approach, involving a researcher from Higher Education, and practicing teachers in schools, producing relevant and robust resources for subject knowledge and the Nature of Science. The project has been successful in these respects:

1. The resources provided are innovative in a number of ways:

a) the use of web sites with optional information and opportunity for blogs, discussion and teachers to create their own pages and upload their own files is innovative;

b) the use of newspapers for revealing history of science, in pupil-level language, is unusual for both pupils and teachers;

c) recreating historical experiments is unusual in these teachers' experience

d) the use of play scripts for recording and assessing learning is unusual.

The project represents work in progress. Nevertheless, there are some clear implication from the project to date:

1. More resources for teaching HPS are needed and have been provided by the project.
2. Curriculum materials that mesh with the curriculum are more likely to be readily accepted.

3. Teachers need more time in preparation and in evaluation if curriculum change is to be securely embedded in their practice.
4. Some innovative pedagogies such as producing play scripts, and newspapers, can support increased engagement by pupils, and by teachers who also use them as a source of personal knowledge.
5. Developing curriculum resources for such a novel area demands considerable time for discussion with the teachers, and better access to appropriate equipment.

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ATTITUDES OF SOME BRAZILIAN STUDENTS CONCERNING THE THEORY OF BIOLOGICAL EVOLUTION

Acácio Pagan

Federal University of Sergipe (*Universidade Federal de Sergipe/NPGECIMA*)

apagan.ufs@gmail.com

Graciela Oliveira

Federal University of Sergipe (*Universidade Federal de Sergipe/NUBIO*)

graciela.ufs@gmail.com

Nelio Bizzo

University of São Paulo (*Universidade de São Paulo/PPGEducação*)

bizzo@usp.br

ABSTRACT

The theory of biological evolution is essential in order to understand the diversity of living organisms, although it is still controversial in certain social groups. We reported a piece of research carried out in order to comprehend the acceptance or rejection of biological evolution by Brazilian students of two different groups from Tangará da Serra, in the Amazonian region, the groups were: High School freshperson students and Undergraduate students seeking a Biology degree. The information was collected with questionnaires using Likert scales. Two hundred and ninety-four (294) questionnaires were filled out by high school freshperson students and one hundred and fifty-nine (159) questionnaires were filled out by undergraduate students seeking a Biology degree. Students' scientific knowledge and religious beliefs were significantly correlated. In both groups, it was observed that attitudes in opposition to evolutionary orientations were influenced by religion and it is more evident in females, who proved to be more committed to religious activities.

Keywords: *Teaching of biology, evolution, religion.*

INTRODUCTION

The tension between understanding and acceptance of the evolutionary theory has been widely discussed among researchers of science studies (Alters and Alters, 2001; Hokayem and Boujaoude, 2008). Some point towards student immaturity to understand this theory; others speculate that the professors have not approached this theme in an adequate manner to motivate student learning; and a third group shows that, in some cases, students simply reject evolution due to religious explanations constructed in their family context and which account for the origins and development of living organisms (Alters, 2005; Sinatra et.al., 2003; Cobern, 1994). Therefore, in this work, we attempted to comprehend the acceptance and rejection of evolutionary theories by students from Tangará da Serra city in Mato Grosso, Brazil, from consulting two groups: 1) high school freshperson students; 2) undergraduate students seeking a Biology degree.

MATERIAL AND METHODS

The information was collected with questionnaires using Likert scales. A scale can be defined as a collection of items used to determine the distribution of a given characteristic in a population. It is a group of values that represent qualities, for example, behaviors, objects and interests (Ary; Jacobs and Razavieh, 1972). The scale is also called an additive scale since the sum of a group of items discusses a latent matter. Ary, Jacobs and Razavieh (1972), comment that the additive method comprises the presentation of a number of positive and negative phrases about an attitude object. Each one of the phrases admits to five responses, whereby the individuals indicate how much they "strongly believe", "believe", "are undecided", "disbelieve", or "strongly disbelieve" in the affirmation. It is important to mention that an original Likert scale permits a neutral option and comprises alternatives in odd numbers. A scale that does not present this number of categories is also called a "Likert-like scale". Some researchers have elaborated scales consisting of only four options so as to ensure that the responder takes a stand in the matter. For Hill and Hill (2004), there is no rule concerning the number of options; however, the second form of inquiring is normally linked to the search for more intimate and delicate responses.

In the research carried out in the scope of elementary education, the questions elaborated were adapted from the ROSE questionnaire – Relevance of Science Education. This instrument was developed in the University of Oslo (Norway) by the Department of Teacher Education and School Development (Faculty of Education) and aims to verify the importance of science and technology learning and the various factors that influence the motivation to learn science and technology related contents from the perspective of 15 year students of different countries. This questionnaire was elaborated using closed questions and fixed alternatives in a Likert-like scale of four options. In Brazil, the translation/adequation of the ROSE questionnaire respected the structure and order of questions and five questions were added on the themes: biological evolution and religion. According to Schreiner and Sjoberg (2004), this format is simpler compared to others when constructing phrases as well as responding to them. However, it presents a greater assurance in comparative studies. These questionnaires were applied to 294 recently registered high school students in a large school in Tangará da Serra - MT, being that these students came from 37 elementary schools in the region. These students presented a mean age of 15 years (32.2% students below 15 years; 49.0% aged 15 years; and 18.8% above 15 years) and a majority of them were females (58.4%). In relation to religion, a majority manifested themselves as participants of the catholic church (66.9%); in second place were the evangelics with 23.2%; 8.32% denied any religion and 1.42% were grouped in the category of other religious beliefs.

One hundred and fifty-nine (159) questionnaires were applied to higher education students of Biological Sciences of a state university also in Tangará da Serra, using Likert-like scales with five alternatives. In this case, neutral responses were permitted. In the questionnaires these responses were represented by the option "Neither agree nor disagree" and appears as *indifferent* (I) in the results. Schreiner and Sjoberg (2004) explained that the neutral category has been excluded from the analyses since it normally generates ambiguous responses. Mostly, the responders do not consider the neutral category to be an intermediate between the extremes: they could therefore choose this option due to lack of knowledge in the subject, failure to understand the matter, lack of motivation or a refusal to respond. Some works have also shown that there is a greater tendency to choose this option compared to the others. For one to show neutrality about a topic can be easier than siding.

In the case of the university students, the neutral response was permitted as long as they presented maturity and knowledge to understand the meaning of neutrality. During application of the questionnaires, they were oriented not to respond to questions they did not understand, so as to avoid ambiguities. The majority of the responders were females (74.8%), aged between 19 and 21 years. The majority of students manifested themselves as Catholics (51%); 19.7% stated they believed in God, but were not part of any religion; 16.6% identified themselves as protestants; 5.7% responded that they were atheist or agnostic and 3.2% referred other religions. The analyses were carried out after processing using statistical software from the description of frequencies, spearman correlation tests and nonparametric analyses of variance.

RESULTS AND DISCUSSION

In general, 80.2% of the undergraduate student interviewees understand that evolution is important in their daily life and 70.8% agree that removal of evolution teachings from the school curriculum would be a disadvantage. Although 74% believe that the evolutionary theories present important steps in the right direction, only 46.7% have the same opinion when the discussion focuses on human beings, 40.9% of the students showed that they do recognize conflict between learning evolution and their cultures. On the contrary, 35% believe that such theories are opposed to their cultural values (table 1).

Table 1: Attitudes of some Brazilian university students concerning Biological Evolution

"On evolutionary theories studied in school or in the university [...]"	TD*	D	I	A	TA
The evolutionary theory can contain some imprecisions and open questions, but signifies a great step in the right direction	1.9%	7.8%	16.2%	58.4%	15.6%
The evolutionary theory is a combination of worthless assumptions for my life	32.1%	48.1%	10.9%	3.2%	5.8%
The evolutionary theory is contrary to cultural values that are important for me	11.7%	29.2%	24.0%	21.4%	13.6%
The exclusion of teaching Biological Evolution from the syllabus could be a step backward	8.9%	10.8%	18.5%	38.9%	22.9%
I believe the explanations offered by the evolutionary theories on the expense of the origin of human beings	10.5%	15.1%	27.6%	38.8%	7.9%

***TD – Totally Disagree; D – Disagree; I – Indifferent; A – Agree; TA – Totally Agree;**

The questionnaire was given to undergraduate students who were asked their extent of commitment to religious activities (individual, family and community); their responses varied from *not at all* to *very strongly* committed (figure 1). It is possible to realize that a majority of the university students have a strong or very strong sense of well-being just by participating in religious activities. They mainly develop individual or family religious activities and about half of the students believe that their theological knowledge is significant.

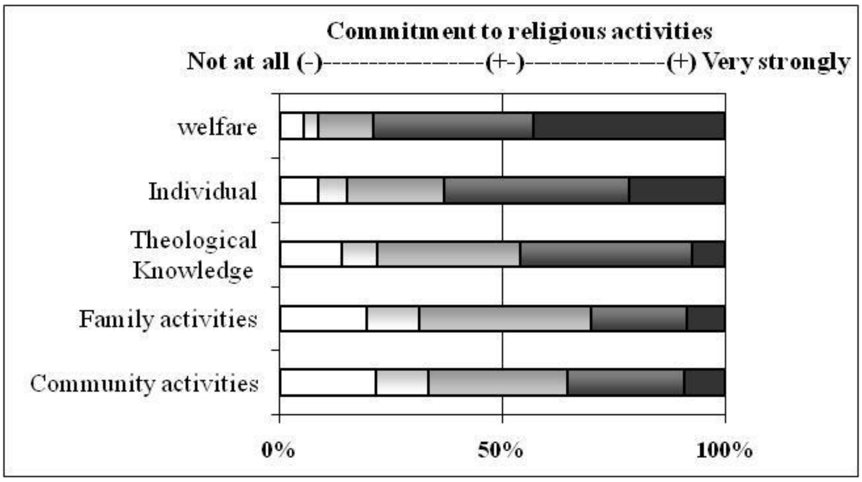

Figure 1. Frequency distribution according to intensity and type of participation of university students in religious activities. Cronbach's Alpha = 0,877

From these answers, it was evident that those who were more committed to religious activities manifested the greatest rejection to evolutionary theories (Spearman's ρ -0.460, sig. 0.01). Among these students were the Evangelics (Kruskal-walis, p=0.004). The females manifested themselves to be more committed to religion when compared to males, considering that they tended to respond *strongly* or *very strongly* committed (Mann-Whitney U, p=0.000).

Similar information was found in the analysis of the high school freshperson students. The difference in participation frequencies in religious activities calls for attention, the females (46.4%) manifested themselves to be more frequent participants in religious activities than the males (29.7%) (Mann-Whitney, p=0.001). Apart from this, the proximity to religion is also mentioned in the question that measured the Tangará da Serra students' attitudes as there was a 72.4% correlation in the item *I am a religious person,* and *one with faith*; and a 74.9% correlation in the component *I understand* and *I believe in religious doctrines and teachings*. Regarding the high school students' attitudes towards biological evolution topics, evolution evidences based on fossil registrations (61.2%), as well as common ancestry (66%) and natural selection (66.5%) are accepted with high concordance levels. Although the concordance levels are low, students tend to accept the components concerning the origin and evolution of the earth (49.7%). After summing the results, we observe rejection sentiments of items referent to the origin and the evolution of human life since 55.3% of the interviewees disagreed with items in this topic.

Table 2: Attitudes of some Brazilian university students concerning Biological Evolution

Item	TD*	D	A	TA	NR
The fossils are an evidence of species that lived in the past and that are currently extinct.	12.2	20.1	27.2	34	6.5
The present animal and plant species originated from species in the past.	12.6	13.6	33.7	32.3	7.8
If a live human being can live well in an environment, they can have many descendants with advantageous characteristics.	11.2	16.3	39.1	27.4	6
Human beings originated in the same manner as other biological species.	28.1	27.2	20.9	15.4	8.4
Conditions of the primitive earth favored the occurrence of chemical reactions which transformed inorganic components into organic components, which in turn generated life.	19.4	21.4	28.6	21.1	9.5

***TD – Totally Disagree; D – Disagree; I – Indifferent, A – Agree; TA – Totally Agree; NR – No Response**

The Evangelic students also tended to strongly reject evolution, more than the others (Kruskal-Wallis, p=0.005). It was observed that students adopted different attitudes regarding scientific knowledge depending on the association they had established with the religious dogmas. Apart from this, the adolescent females of this group were more intense church goers than the males (chart 1).

Chart 1: Multiple comparison between the mean of religious groups in Tangará da Serra – MT

Variables	Catholic	Evangelic	None	p-value
Evolution	29.63 (±5.59)	26.89 (±7.00)	31.29 (±6.24)	0.002

N=294 α Cronbach= 0.754

In the case of university students, when the variables related to evolutionary tendencies were tested in relation to progression of students in the course, significant results were not obtained. We mention that the syllabus and the pedagogical structures of this course are being re-structured, but it was not possible to obtain more recent data on the matter. It is important to point out that syllabuses in other courses in Brazil present similar characteristics as presented by Goedert (2004).

Goedert (2004) aimed to analyze elements of initial training and teaching practice that contribute to teaching of Biological Evolution. A case study was developed using application of questionnaires, together with seven Biological Science professors of the Federal University of Santa Catarina, who graduated between 1989 and 2000. These professors, based in Florianópolis and São José, presented a five-year mean of experience in Elementary Education and were aged 28 to 35 years.

These professors manifested difficulty in working with evolution perspective in classrooms, especially due to problems associated with initial training. Among the problems leading to these difficulties, they pointed out that what they had learnt about evolution was not sufficient for their post-graduate needs. They also pointed out the disarticulation of evolution perspective from other specific subjects in Biology, as well as the university degree (Goedert, 2004).

Tidon and Lewontin (2004) developed similar considerations to those developed by Goedert (2004) when they pointed out that there was inaccessibility to knowledge on evolution for researchers as well as professors. This shows that the problem is not specific to the university investigated in this research. However, according to the study developed by Tidon and Lewontin (2004), this problem can also reflect on pedagogical activities implemented by these future professors and consequently on their students.

Greene (1981) considered that Western thinking comprised an interaction between religious, philosophical and scientific ideas. He also analyzed the mutual influence between Evolution and Christian thinking, natural theology and social sciences. According to him, the impact generated by evolution ideas in areas like philosophy and religion was much stronger than that in the scientific field.

An example of Greene's observations (1981), scientific and religious knowledge, constructed by investigated students showed this intense relation. In this research, it was observed that the students' points of view concerning evolution were influenced by their religions as well as the degree of commitment to religious activities.

Students who referred a greater proximity with different types of religious activities (individual, family or community) tend to be more distant in terms of evolution orientations, especially the Evangelics. Females were more committed to the religious universe than the males. They also presented the least proximity with the evolution perspective. According to data gathered together with high school students, it is possible to infer that these behaviors have been constituted based on influence of the religious education by the students' families.

Results obtained from the High School students showed that these students accept the evolution evidences based on fossil registration as well as common ancestry and natural selection. However, there was significant rejection of theories concerning the origin and evolution of the earth and human beings. Apart from this, the female adolescents in Tangará da Serra were more frequent church goers than the males. According to Blackwell, Powell and Dukes (2003), it is possible to accept an evolutionary theory with or without a discussion of events in the evolution of *Homo sapiens sapiens*. The authors also asserted that acceptance of the evolutionary theory or its constituent would represent a significant step toward understanding this theory.

Rejection of evolution has been classified in scientific works as a creationist attitude. Although creationism is considered to be a political movement, its bases are embedded in religious values. This political dimension is mainly centered in the United States of America where a number of nongovernmental organizations support anti-evolution actions.

In Brazil, the creationist attitudes are still incipient and currently do not characterize a political movement, like it is in the United States of America. For this reason, in this research, we speak of creationist tendencies, but not of creationist groups since we aim to highlight the influences of some religious attitudes on acceptance and rejection of evolution, without allusion to politically organized creationist groups. However, different motivations to reject the biological theory are found in the attitudes of students of different schooling levels. Alters and Alters (2001) discuss that they can be religious or nonreligious, as well as a combination of both. The results found with elementary education students and high school students point towards the existence of an association between rejection of some topics referent to the evolutionary theory and religious beliefs.

Alters and Alters (2001) described four subgroups within creationist groups: Literalists, Progressives, Theists and the Intelligent Design. According to these authors, many *Progressives*, compared to the Literalists, are more flexible in their beliefs. They understand that biblical texts can be interpreted according to contexts in which they were written. To this group, the Earth was created by supernatural forces, as explained in the biblical texts; however, the creation days described in Genesis can signify time intervals that can reach millions or billions of years. They also consider that humans and other living organisms were created by God, and that Adam and Eve were the first human beings. The divine forces occasionally intervene on Earth, especially in the creation of new organisms (Alters and Alters, 2001).

Theists are characterized by refuting the idea that Evolution occurred without the intervention of supernatural forces. They can be divided into two groups. The first group defends that chance has minimum influence on evolution or it is not altogether existent. The evolutionary theory is conditioned to God’s decision, who guides the whole process. They also denominate themselves as Theistic Evolutionists (Alters and Alters, 2001). The second group understands that the Evolution process involves an authentic random element, but God planned this mechanism while purposely attempting to produce humans. This group is also denominated as Intelligent Design. To some defenders of Intelligent Design, the deviser is not necessarily a biblical divinity, but can be any other type of supernatural or foreign force (Alters and Alters, 2001).

Pagan (2009) presented complementary data about the same university students consulted in Tangará da Serra. He constructed a scale that contained affirmations of creationist orientation from the four perspectives. Analyses of the presented frequencies by items that composed them allows inference that for a majority of the students, creationist tendencies are linked to characteristics of the Progressive and Theistic groups, mainly because three fifths of the students agree on the existence and influence of God on the Universe, as well as on the biblical explanations on the origin of life. However, to this larger group, the Christian Sacred Book is not the maximum authority concerning daily topics.

Sepúlveda (2003) aimed to characterize the strategy used by a group of protestant students, in Biological Sciences Licensure of the State University of Feira de Santana (*Universidade Estadual de Feira de Santana – UEFS)* in Brazil, to associate scientific and religious knowledge. She applied semi-structured interviews to five protestant students of the sixth and last semester of the Biological Sciences Licensure course at *UEFS*. This researcher realized that some students distinguish scientific and religious discussions, using them in their respective contexts. However, they feel the need to learn the scientific perspectives so they can integrate them into their religious beliefs.

To one of the students interviewed by this researcher, scientific knowledge does not bring her satisfaction or comfort considering uncertainties due to the conjectural nature of scientific theories. This is something she finds in biblical literalism owing to the idea of absolute truth (Sepúlveda, 2003).

To Alters (2005), a discovery of why the students reject Evolution and how they feel about this topic can help professors to increase the teaching-learning relationship since rejection is mostly supported by complex cultural fundaments.

The data analyzed by Pagan (2009) identified that less creationist students have more instructed parents. This condition suggests the influence of Higher Education on the re-significance of religious family values, what identifies family as a significant influence on those who decide to consider the Teaching of Evolution. If family can be a strong corroborator for a creationist orientation, not knowledge of evolution itself, but a dynamics of the knowledge constructed during undergraduate studies can be an important factor to reconstruct such values in the home context.

In profiles of university students interviewed by Pagan (2009), the same students consulted in this work, two types of family settings were identified: students who live in a nuclear family setting and those who live alone, with their friends or husbands and wives. Some statistical tests showed that students who live by themselves have a greater proximity with the scientific universe and also with the evolution perspective. Interpretation of this information suggests that students living on their own are less influenced by religious family values since they are not routinely influenced and are more exposed to daily decision-making that increases their chances to develop autonomy.

This analysis seems to indicate that students who separate themselves from religious values can search for new ways of understanding their own human identity, their origins and future perspectives in a discussion that is more compatible with Evolution.

The religious beliefs tend to have an important role in the manner that an individual perceives the theory of biological evolution. In the case of science professors, it can influence the decision to teach or not to teach the theme in classrooms. Alters and Alters (2001) highlight that omission of biological evolution theory is common in North American science syllabuses in all schooling levels, although more frequent in elementary education. It is not different in Brazil since, according to Tidon and Lewontin (2004), biological evolution is normally taught in biology classes, at the end of the 3rd year of high school, fragmented in relation to other discussion themes and disconnected from themes discussed in previous schooling years. Time dedicated to study biological evolution in public schools is insignificant.

While they study the sentiments and worries of future Canadian professors regarding the teaching of biological evolution in elementary schools, Asghar, Wiles and Alters (2007) discuss that future professors accept the theory of biological evolution and intend to include the teaching of this theory in the elementary school syllabuses. However, there is a concern among the professors regarding the acceptance of this theory by students and their parents since the inclusion of evolutionary theory in science can confront the students' religious beliefs. Another concern of the future professors is the impression that their academic formation did not contribute to an adequate understanding of the theory and did not offer a theoretical basis on pedagogical strategies to deal with controversial themes in classrooms.

Opposition towards the theory of biological evolution, common in the conceptions of the future professors as well as those of the high school students, is related to cultural and social environments in which they are inserted. Since the religious beliefs seem to be striking even among the future professors, it is necessary to think how these professionals will intermediate their personal beliefs and teaching of the theory of biological evolution just as it is necessary to think how this science professors will cope with their students' reasons to reject the evolutionary theory, and the cultural context that supports the rejection.

CONCLUSIONS

Rejection of the evolutionary theory due to influence by religious matters is manifested by the interviewed students in elementary as well as higher education. They present a nucleus of religious opinions on the origin of the Earth and human beings, a system of beliefs that accompany the students to classrooms, contradicting scientific knowledge.

The scientific and religious knowledge constructed by the interviewed students were significantly related. It was observed that the contradictory attitudes to evolutionary orientations are influenced by religion and manifest themselves strongly in females, who demonstrated to be more committed to religious activities. In this context, the evolutionary theory seems to be influenced mainly by social and cultural characteristics of the environment in which these students live. In both schooling levels, high school freshperson and undergraduates, the students rejected contents of items which referred to the origin of human beings from evolutionary explanations.

In the two groups that were studied, it was observed that part of the scientific knowledge on the theory of biological evolution was accepted. A possible association between rejection of some aspects of the theory of biological evolution and affinities with religion suggest that the presence of different theories to explain the human existence can interfere with the student's attitude to a theory. In this sense, it seems important that students comprehend how to distinguish epistemological differences between knowledge explaining the origin of the universe and that explaining the origin of life.

Discussions on the nature of science can contribute to understanding processes of construction and manifestation of scientific thinking. However, according to some case studies presented in this work, it is possible to realize that there are contexts in university and elementary courses that still present evolutionary thinking as a body of disconnected concepts to biological thinking. The curriculum offered in the Brazilian Elementary Education favors scientific enunciations, only promoting memorization of facts, rules and scientific theories to the detriment of comprehension that science is a dynamic process, influenced by various factors, mainly, human activities.

A curriculum that favors elucidations about the nature of science is essential for the students to comprehend the distinctions between scientific, religious, cultural and philosophical knowledge, among other knowledge models that aim to explain the world. It is also essential to comprehend that any knowledge is valid in the context in which it is produced, without the need for ranking. They are forms of knowledge with different epistemologies.

These data should be compared in future researches of curriculums of training courses for Biology professors, considering that they do not have a large influence on High School students and future professors.

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TRANSFORMING SECONDARY SCIENCE EDUCATION THROUGH 'CONTEXTUAL' PROFESSIONAL LEARNING FOR TEACHERS

Debra Panizzon

Flinders Centre for Science Education in the 21st Century

debra.panizzon@flinders.edu.au

Martin Westwell

Flinders Centre for Science Education in the 21st Century

martin.westwell@flinders.edu.au

Mark Ward

Flinders Centre for Science Education in the 21st Century

mark.ward@flinders.edu.au

ABSTRACT

Engaging students in science so that it is meaningful requires science teachers to think 'outside the square'. This is critical given the impending shortage of engineers and physical scientists that is evident in many OECD countries with emerging issues already prevailing in Australia. However, if science teachers are to re-think their pedagogy and update their scientific understanding in a manner that supports student learning they require access to the necessary expertise. This paper outlines a program set up to support secondary science teachers in achieving this goal by allowing them to design school-based projects relevant to the specific needs of their students. By accessing and incorporating expertise outside the school students became more aware of the relevance of science to their lives and better informed about science-related careers. Similarly, science teachers were able to enhance their scientific understanding and skills while exploring a range of mechanisms for engaging their students in science. Most important was the realisation that if teachers are to be agents of change they must be able to access support and expertise *when relevant to their teaching* so that authentic professional learning occurs.

Keywords: *making science meaningful, teacher professional learning, industry engagement*

INTRODUCTION

Within Australia there is much evidence available about the drop in the number of students selecting science from Year 10 into Years 11 and 12 (DEST, 2006; Fullarton et al., 2003). Importantly, this phenomenon is not unique to Australia with many OECD countries facing similar difficulties in terms of student participation and engagement in the enabling sciences in the secondary years of schooling (i.e., physics, chemistry and mathematics) (Osborne & Collins, 2001; OECD Global Science Forum, 2006; Sj∅berg & Schreiner, 2005).

The impact of individual teachers on student engagement and achievement is well documented in the research literature (see Hattie, 2003 who considers a meta-analysis of some 500 studies). However, if cohorts of students are to be enthused and encouraged into the enabling sciences, faculties of teachers need to be able to work as a team in a cohesive and supportive manner. Recent studies in this area undertaken in New South Wales schools achieving high value-added outcomes for their students highlight a number of key features common to successful faculties (Ayres et al., 2004; Panizzon et al., 2007; Pegg et al., 2007). These include:

- Collaboration and commitment to the faculty group by individual teachers;
- High standards and expectations of students and teachers shared across the faculty and school;
- Interest, enthusiasm and passion for science and mathematics evident in the teachers;
- Quality pedagogy with a high degree of mentorship of young or inexperienced staff;
- Sharing of resources and collaborative assessment practices with all teachers involved in the process;
- Service by staff within the school for 8-10 years;
- Commitment to maximising learning outcomes for all students; and
- Support from senior executive in the schools.

Focusing on pedagogy particularly, one of the most significant areas of concern to emerge from research studies is that school science is perceived by many students to be irrelevant and ‘boring’ (Goodrum et al., 2001; Osborne & Collins, 2001; Tytler, 2007). A mechanism for addressing this perception of students is by moving towards a ‘contextual’ approach to the teaching of science and mathematics with a greater focus around the relevance of these subjects to society (Fensham, 2000; Rennie & Goodrum, 2007). Such an approach requires changes to the content of the curriculum and the pedagogical approaches used by teachers in the science classroom by developing links with industry, higher education institutions and expertise within the local community. Importantly, if science teachers are to embrace these changes they too need access to professional learning that supports, challenges and builds their subject discipline and pedagogical knowledge in an ongoing and dynamic manner (Loughran *in press;* Watson & Manning, 2008).

This paper presents the findings from a project set up to support teachers engage students in science through the establishment of links with scientists and engineers in their local community. While the aim of project was on student engagement, as demonstrated from the literature above, this is not possible without teacher engagement and commitment. Here we provide an overview of the context of the project, the process used in working with teachers in schools, and the research design underpinning the project. Findings focus primarily around the impact on science teachers although some student data is presented to demonstrate that change in their engagement with science was clearly evident.

SCHOOL TO WORK: SCIENCE INNOVATION PROGRAM

The main purpose of this program was to support teachers in making science more meaningful for students in Years 10, 11 and 12 in South Australia. To achieve this end, each participating school developed a project around a specific context (e.g., Defence or Mining) with a view to increasing levels of student engagement and awareness while enhancing aspirations to continue along science-related pathways. For example, in one school the focus for science was to increase student awareness of the alternative career pathways around engineering and science using a Defence context. Alternatively, in a school catering for a lower socio-economic clientele, science teachers set out to raise student self-efficacy and confidence as a means of enhancing student engagement in school science and mathematics.

To support projects each school was allocated approximately $14 000 for the year. While there was a degree of flexibility for teachers to design and implement a project appropriate to the needs of their particular students, an underlying premise was the establishment of links with scientific expertise in industry, universities and other institutions. Taking the example of the school using the Defence context above, one of the mechanisms used initially for getting students to engage with expertise in industry was to run a 'speed dating with engineers' event. Having briefly met and chatted to a number of experts, students selected a project for exploration working with this expert.

As such, this structure allowed science teachers to select a context relevant to their cohort of students and to negotiate the expertise necessary as required for the duration of the project given that funding was available. In addition to supporting the needs of students, a professional learning community for the science teachers was created across the schools facilitating the sharing of ideas, resources and scientific expertise.

Process for working with teachers

Each school in the project was expected to (i) involve a core group of science teachers (including coordinators); (ii) ensure regular meetings of the staff involved to facilitate communication and sharing of ideas; (iii) use a major proportion of the money for Temporary Relief Teachers (TRTs) so that teachers involved could allocate quality time to the project; (iv) allocate the remainder of the money to financially supporting the involvement of scientific expertise when required; and (v) demonstrate that the senior executive (e.g., principal and/ deputy principals) supported and endorsed the project.

The core document for each school was an Action Plan that detailed the particular strategies to be developed, the expertise and industry links to be established against a timeline, and budget. The project team critiqued these plans with suggestions made where appropriate.

Throughout the year each school was visited on a number of occasions by the project team with a Project Officer permanently available via phone and electronically. In this manner teachers were supported while being able to access the expertise they required as the need arose *within their teaching context*. To ensure that the projects in each school maintained focus, two sharing days were held with each team of teachers required to report back to the whole group about the progress to date. These days were held in July and December 2008.

RESEARCH METHODS

Fourteen secondary schools representing government, catholic and independent systems participated in the program. These schools were selected using a number of criteria by a panel including members of the project team and senior educational officials.

The research design was interventionist with baseline data collected using a number of sources prior to commencement and at the completion of each project. Initially, students in each school completed an online survey consisting of 95 Likert scale items taken from the attitudinal survey used for PISA 2006 (OECD, 2005). These covered a number of constructs including: experience of school science, enjoyment of science, self-efficacy in science, self-concept in science, general and personal value of science, views on science, sources of scientific information, interest in learning science, awareness of environmental issues, motivation to learn science, and teaching and learning science. The survey took 25-30 minutes to complete.

Interviews were undertaken with the principal and science team involved in the project in each school. These data provided a baseline to monitor any changes in student attitude and engagement along with impacts on science teachers.

With initial data collected, projects were implemented over a 7-month period. Upon completion, students undertook the same survey while interviews were again conducted with the science staff in each school. Finally, each school produced a case study report, which documented the processes used for project implementation along with the successes and associated issues that emerged. These reports were collected for documentary analysis.

Student survey data were analysed using descriptive statistics to enable comparisons with the Australian data available for PISA 2006. Once the pre and post-survey responses were analysed, the differences between the two sets were calculated as a means of determining any changes in the pattern of attitudes.

MAJOR FINDINGS AND DISCUSSION

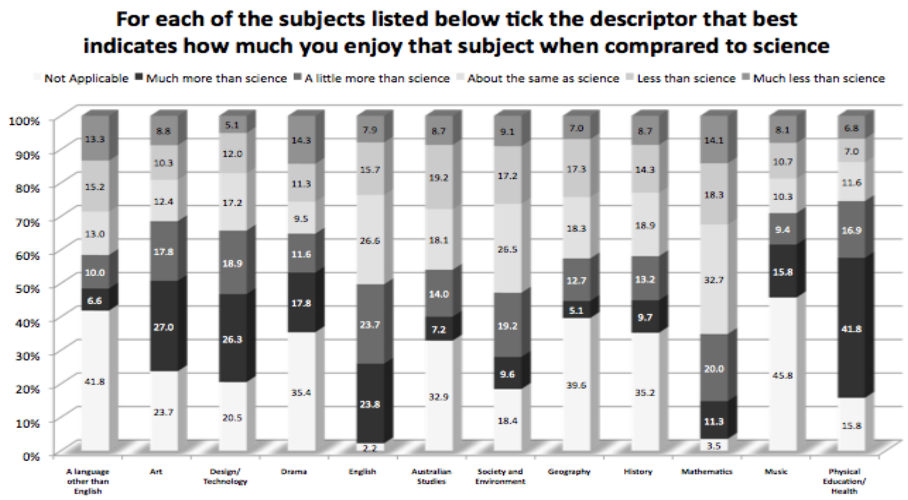
Overall, involvement in the projects led to greater cohesion among science teachers in each of the schools and an increased level of collaboration that was evident by a shift in teacher pedagogy. For students there was an increase in student engagement, particularly regarding their aspirations to continue on science-related pathways from school to work. This shift was evident from the attitudinal changes that emerged from the surveys.

Changes in student attitudes

In terms of student attitudinal changes between the pre and post-project responses, major shifts were noted across the majority of schools. While a number of constructs were explored in relation to the project, data for two constructs are presented here.

Experience of school science

As a group in the pre-survey responses (Fig. 1a) students expressed ambivalence towards science with no greater like or dislike of science when compared to other subjects. The only exceptions to this trend demonstrating greater student enjoyment were physical education, design and technology, art and English. However, over the course of the project, students' preferences shifted towards science and away from other subjects with greater proportions of students selecting the 'agree' and 'strongly agree' options for science in the post-survey responses (Fig. 1b). Figure 2 illustrates the change in student opinion regarding their enjoyment of science as a result of the intervention within each school.



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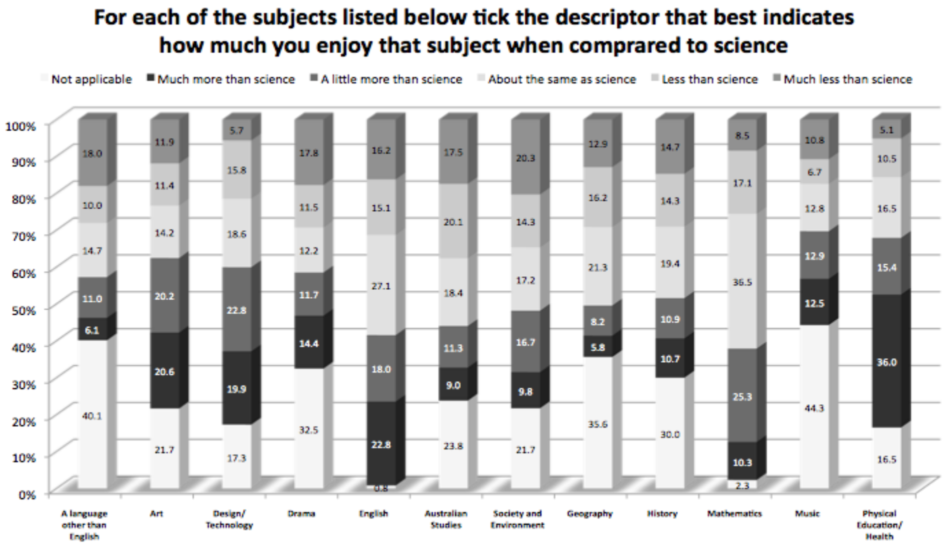


Figure 1. Pre (a) and post-survey (b) responses for students' enjoyment of science

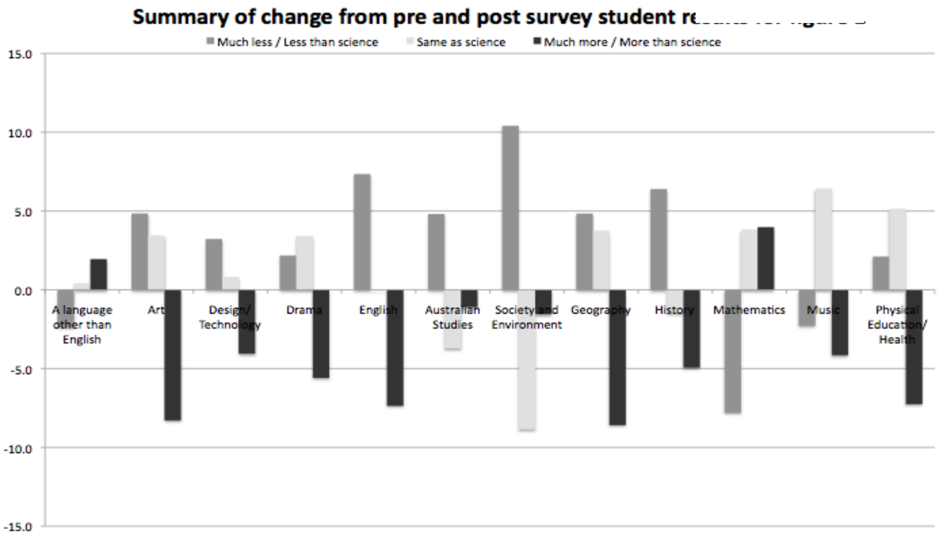


Figure 2. Student enjoyment of science: Differences between pre and post-survey results

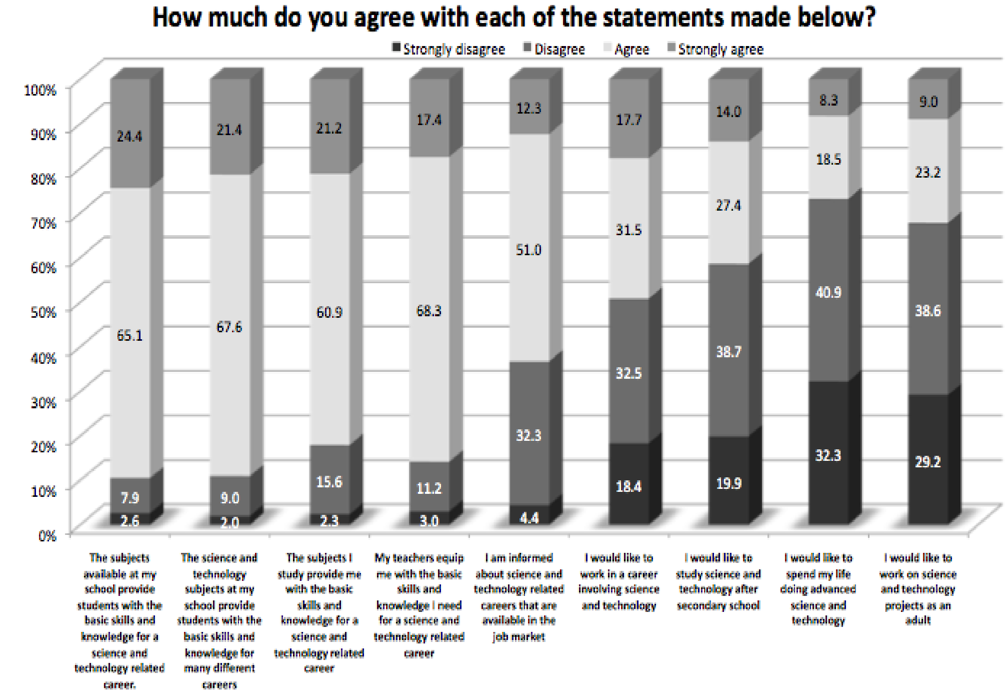
It is clear from these findings that students' preferences for science compared to other subjects increased with the notable exception being mathematics. Surprisingly, this subject experienced a notable increase in popularity compared to science. A possible explanation for this observation was that the science focus of many of the projects tended to highlight the closely linked role of mathematics, which may have provided students with a more meaningful contextual application for mathematics as a subject.

Motivation to learn science

At the beginning of the project (Fig. 3a, first four items), more than 80% of students generally 'agreed' or 'strongly agreed' that school was equipping them with the science-related skills they needed for their futures whether in science, technology, engineering, mathematics (STEM) or related careers. However, after the project (Fig. 3b, first four items) the greater proportion of students were questioning the degree to which their school science experiences were equipping them for their future. This is demonstrated clearly in Figure 4 by the negative results for the first four items, which indicate a decrease in the number of students selecting the 'agree' and 'strongly agree' options on the post-survey.

An interesting finding to emerge for these data is that despite overwhelmingly agreeing that the school was giving them the skills for participation in STEM-related careers, before the project, the proportion of students who aspired to pursue a career in the STEM-related areas was low (though slightly higher than the state and national averages for Australia for PISA 2006 (Thomson & De Bortoli, 2008) (Fig. 3a, last five items). However, after the project (Fig. 3b, last five items) there was a considerable increase in the proportion of students aspiring to follow pathways to STEM-related careers (see Fig. 4). So much so that the proportion of students who "would like to study science and technology after secondary school" and those who would like to "spend [their lives] doing advanced science and technology" rose to more than double the PISA national and state averages for Australia (Thomson & De Bortoli, 2008).

a



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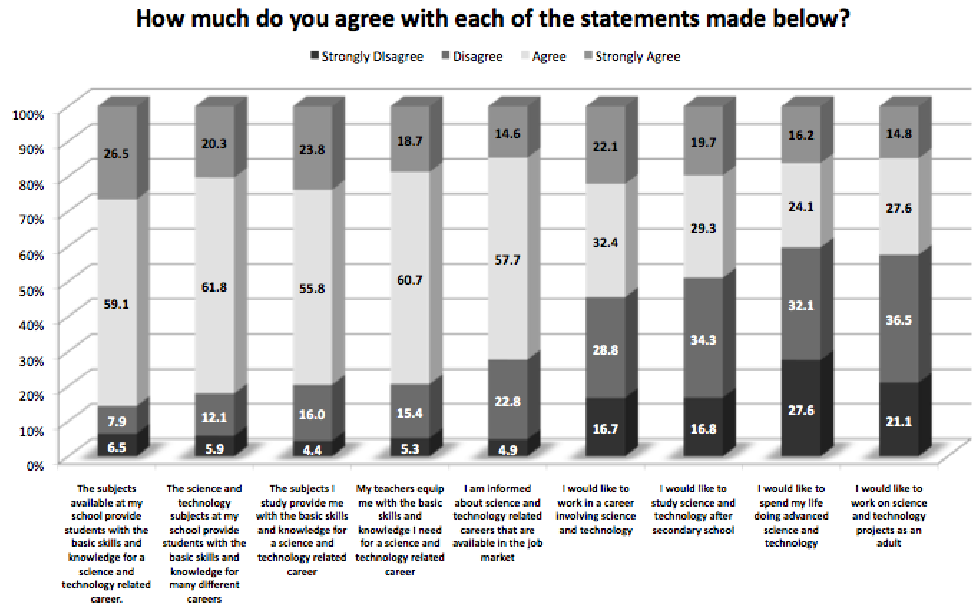

Figure 3. Pre (a) and post-survey (b) responses for students' motivation to learn science

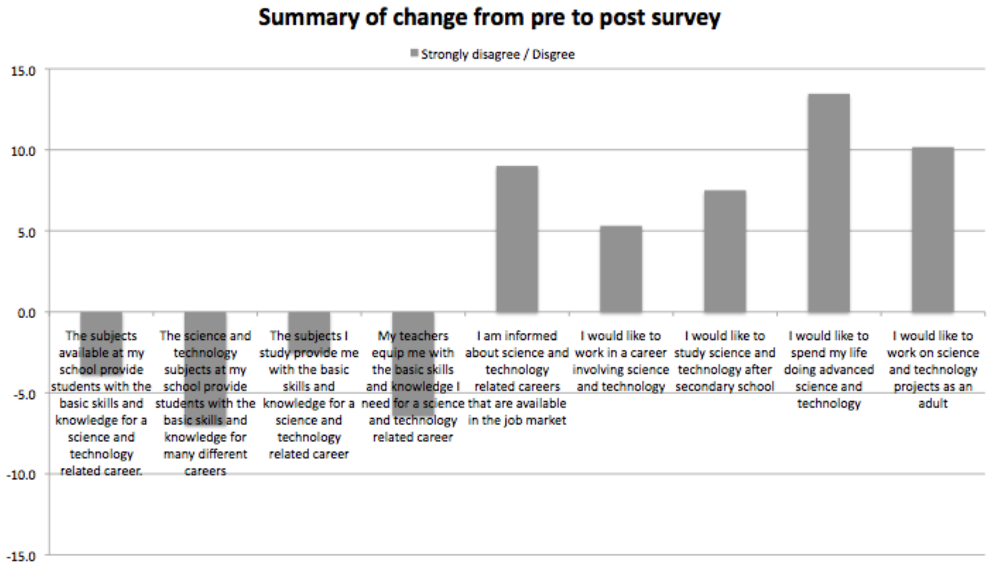

Figure 4. Student motivation to learn science: Differences between pre and post-survey results

In addition to these survey results, other aspects around student engagement noted by science teachers in their school case study reports included:

- increases in student satisfaction (often recognised by teachers outside of the science faculty);
- increases in student uptake of physics and chemistry at a senior secondary level (i.e., Years 11 and 12) in the majority of the schools;
- decreases in student behavioural problems; and
- increases in student attendance records in a number of schools.

Changes in science teachers

The central theme that emerged for teachers was a perceived improvement in the nature and quality of their relationships within the school. This occurred within the science faculty and with staff-student relationships.

> *It was really interesting that both the staff and students responded well to what was happening in science. As teachers we seemed to establish a stronger rapport and others noticed a change in the way in which they related to the students. We even had teachers from other faculties comment on how engaged the students seem to be with their science* (Science teacher).

It is this central and fundamental factor that has been demonstrated in previous research (see Panizzon et al., 2007) as it forms a cornerstone for the nature and quality of the learning experiences for students in science. Yet, establishing and maintaining these relationships are time consuming and require the opportunity for ongoing communication. In terms of staff-staff relationships, evidence emerged of consolidation 'as a team' with a high degree of collaboration and unification rather than a series of individuals working on a particular project. The allocation of time to physically meet, share ideas, work together, and discuss particular aspects provided informal professional learning within the school that helped establish a precedent for working collaboratively into the future.

> *Sustainability is possible because people have been able to collaborate and are prepared to work together … We've set a tone if you like of how to work together and that's going to be something that we will build upon and sustain by using our faculty meetings more effectively* (Science coordinator).

A number of the science teachers referred to the importance of having a single focus around the project as a means of helping create the necessary synergy. Being able to concentrate efforts and build upon the skills and expertise of the teachers involved in the projects collectively helped ensure greater impact for students, teachers in individual schools, and the broader school community.

In the majority of cases, it was increased levels of reflective practice that was critical in helping teachers monitor student engagement, involvement and achievement in relation to the scientific experiences. While a number of teachers spoke about their own personal reflections, it was the opportunity to extend this to the broader network that became particularly insightful.

> *It was the continuous discussions, continuous monitoring of students' achievements in relation to what we were doing that really helped me. I became more engaged, more involved as there were less communication barriers and a more friendly feel. Having access to a network of teachers in the same boat as me was so incredibly supportive* (Science teacher).

Overall there was increased engagement and enthusiasm from the teachers involved in the projects within their own schools. At least 90% of science teachers commented in their final interviews that they felt “re-energised and re-invigorated”. For one teacher there had been a significant reduction in stress levels because of the increased collaboration, access to external expertise, a network of science teachers, and the change in the attitudes of students in the classroom.

> *This project left the team more enthused and ideas for further units have already been floated. Our engagement in non-traditional ways of teaching has helped expand our pedagogy* (Science coordinator).

> *The staff is a lot happier because before we had a lot of behaviour issues but there are now quite a few less student behaviour management problems* (Science coordinator).

In relation to accessing expertise in industry, university and the community, teachers considered this to be critical in allowing them to upgrade their own scientific knowledge and their understanding of career options in the enabling sciences (chemistry, physics and mathematics). This highlights the value of thinking about these links at two different levels. The first might be directed towards teachers and the opportunity for them to engage with scientists and experts as a means of improving their personal understanding within the science discipline area. The second with a focus on student engagement with ‘real world science’ and the kinds of experiences that help broaden their awareness in terms of future careers options.

Pedagogy also became a target in the majority of schools as science teachers trialed new strategies to engage their students. For example, teachers commented on their move away from ‘chalk and talk’ and the use of textbooks to an increase in the diversity of activities they included in the science classrooms. As a result, engagement in the project and the opportunity to collaborate with peers in the same school and across schools helped to ‘raise the bar’ in terms of pedagogy.

> *I think it has been really positive because there’s been a greater variety of learning activities happening. Students have come into class and it is just not predictable. There is less chalk and talk here and the group work has become more productive. It has certainly raised the bar but we know there is still more to do* (Science teacher).

Discussions with scientists and engineers reiterated the importance of open investigations and the need for science teachers to move away from the traditional recipe-driven, predictable experiments that prevail in most school science classrooms (even though most curricula in Australia refer to inquiry and investigative approaches in science). Additionally, they recognised the need to embed the development of higher-order thinking skills in the science programs to meet the needs of all students but most especially their scientifically capable students. Again, without incorporating this focus into their units of work and science programs the extension of these students was likely to be overlooked from year-to-year. An important observation noted by the research team was that science teachers in general found it difficult to identify scientific activities and experiences likely to provide students with the opportunity of engaging with and developing these higher-order skills.

These latter points regarding access to expertise emerged as being critical for science teachers. Clearly, just as we recognise student diversity so too teachers are located along a continuum of professional learning. Accepting this perspective means that if teachers are to move further along this continuum they need to be able to access discipline expertise and pedagogical knowledge when relevant to their own teaching context. Considered in this way, professional learning is meaningful for teachers as the new ideas can be incorporated into the classroom instantaneously. The following quote exemplifies this point:

> After emailing …, Trudy came out and that was really fantastic for all of us. We were all there together and she showed us Wiki spaces and that was easy. This allowed me to go away and set up my groups with my students and it was all fantastic. Having access to that expertise when you need it is really important - rather than have the training and development and then you forget it before you apply it to the classroom (Science coordinator).

In other words, teachers too require *just in time learning*, which is not provided with traditional professional development approaches used by educational systems globally.

It is important at this point to recognise the difficulty of discerning what changes in teacher and student engagement related to the nature of the actual project undertaken in each school and the impact that simply being part of a research project had on science teachers and then subsequently their students (i.e., the Hawthorne Effect). From our perspective, it was not about micro-managing the individual school projects as we conceded that teachers probably had the best idea about their own situation but needed support in implementation. Rather our focus was around the networking and the quality of professional learning the teachers were able to access and it is often this aspect that is severely overlooked in traditional professional development programs. However, the project is continuing over the next two years with a number of the same schools involved over this period. This will allow longitudinal data to be collected that should provide more substantive evidence about the degree to which the results shared here relate to the projects and teacher engagement with professional learning compared to a Hawthorne Effect.

CONCLUSION

The *School to Work Science Program* provided extensive details about the successes experienced by teams of science teachers as they developed and implemented a range of different scientific opportunities for their student cohorts. Teaching via contexts and accessing scientific expertise available in the community clearly helped to make science meaningful to students. However, critical to the success of this program is that teachers were able to access this expertise, information and support when relevant to their teaching so as to enhance their own professional learning. It was this component that became the major focus of the program rather than the nature of the school-based projects.

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PRIMARY SCHOOL CHILDREN'S INQUIRY ABILITIES AND REASONING.

Nicos Valanides

University of Cyprus

nichri@ucy.ac.cy

Maria Papageorgiou

University of Cyprus

mpapag@ucy.ac.cy

ABSTRACT

The study investigated fourth- and sixth-grade students' cognitive abilities and problem-solving strategies. Eighty students were individually interviewed as they were experimenting with an improvised device. The device consisted of a wooden box with eighth electric lamps in a line and five switches, in another line, which could move up and down. Each interviewee was asked to "think aloud," prior and after any experiment with the device. The lamps and the switches were connected in a "hidden" circuit inside the box, in a way that only one or none of the lamps could light on. The interviewees kept a record of their observations. The results showed that students were inclined to mainly collect evidence from the experimental space. Students also failed to employ the control-of-variables strategy, but they were able to employ a not fully developed combinatorial reasoning. In addition, they had difficulties to effectively organise their results and did not take full advantage of their recorded data. They did not exhibit the ability to co-ordinate their hypotheses with the collected evidence. The results of the study can guide further research for identifying patterns of students' cognitive development and design teaching scenarios conducive to accelerating their cognitive growth.

Keywords: *Scientific reasoning, problem-solving, control of variables, combinatorial reasoning*

INTRODUCTION

The development of scientific reasoning has been the goal of many reform efforts in science education during the last decades. Scientific reasoning broadly defined includes many procedural and conceptual activities, such as, theory generation, experiment design, hypothesis testing, control of variables, data interpretation, coordination of theory and evidence, evaluation of evidence, use of apparatus, performing statistical calculations and many others (Keys, 1994; Zachos, Hick, Doane & Sargent, 2000). Due to this complexity, earlier studies had limited their scopes by giving attention either on the procedural or on the conceptual aspects of scientific reasoning. Klahr and Dunbar (1988, Klahr, 2000) developed an integrated model that incorporated domain-general strategies with domain-specific knowledge. This model conceived scientific reasoning as problem solving that is characterized as a guided search and information gathering task. The model is known as SDDS model (Scientific Discovery as Dual Search). According to this model scientific discovery is accomplished by a dual search process. The search takes place in two related problem spaces, namely, the hypothesis space and the experimental space. Searching the hypothesis space involves the process of generating new hypothesis based on some knowledge about the domain either as prior knowledge or as knowledge through experimentation. Searching the experimental space involves the performance of experiments that will yield interpretable results. Search in the two spaces is mediated by a third process, the evidence evaluation process. Evaluation assesses the fit between theory and evidence, and guides further research in both the hypothesis and the experimental spaces. Although original descriptions of SDDS model highlighted the "dual search," more recent descriptions acknowledge the coordination and integration of all three components (Klahr, 2000; Klahr & Li, 2005). The focus on the evaluation evidence phase has been influenced by the work of Kuhn (1989; Kuhn & Pearsall, 2000), who insisted that the heart of scientific thinking lies in the skills of differentiating and coordinating theory (or hypotheses) with evidence.

In the years since the appearance of the Klahr and Dunbar's model of scientific reasoning (1988), there has been a move toward research in which participants take part in all three phases of scientific activity (Kaselman, 2003; Schauble, 1996;). These approaches are called self-directed experimentation research (Zimmerman, 2000; 2007). In self-directed experimentation studies, individuals learn about a multivariable causal system through activities initiated and controlled by the participants. There are some features that are common to a subset of these studies. The first refers to the time that participants have been involved with the research. In some cases participants got involved with the investigation for one experimental session, while others involved repeated exposure to the investigation environment (Kuhn, 1995; Schauble, 1996). This repeated exposure is known as microgenetic method of study (Siegler & Chen, 1998). Another common feature was the use of a type of external memory system. Participants were provided with a data notebook or records card to keep track of plans and results or access to a computer file of previous trials (Trafton & Trickett, 2001; Gleason and Schauble, 2000). Given the importance of metacognition on such tasks (Kuhn and Pearsall, 2000), it is important to determine at what point students and adolescents recognise their own memory limitations as they navigate through a complex task.

The results of these studies showed common developmental differences between students and adults. Students' performance was characterised by a number of tendencies, such as, to generate uninformative experiments, to make judgments based on inconclusive or insufficient evidence, to focus on causal factors and ignore non causal factors, to have difficulties disconfirming prior beliefs, and to be unsystematic in recording data. The results also revealed differences in experimentation strategies and divided participants as engineers or scientists according to the goal of their experimentation (Schauble, Raghavan, & Glaser, 1991; Schauble, 1996). Thus, students working as scientists attempt to determine which factors make the differences and which do not, and they work more systematically and try to establish the effect of each variable and make an effort to include inclusion and exclusion inferences. On the contrary, students working as engineers attempt just to achieve a desired result, they select highly contrastive combinations, and they concentrate on factors believed to be causal while overlooking factors believed or seemed to be non-causal.

The present study was based on the Klahr and Dunbar model (1988, 2000) and on previous research (Papageorgiou & Valanides, 2002; 2003; 2006; Valanides & Papageorgiou, 2001) and took into account self-directed experimentation research. The study attempted to investigate fourth- and sixth-grade students' problem-solving strategies and related cognitive abilities. More specifically, this research investigated students' ability to form and test hypotheses, to control variables, to coordinate theory and evidence and to apply combinatorial reasoning.

METHODOLOGY

Initially, ten elementary schools were randomly selected from a geographical district of Cyprus and, from each school, a fourth-grade and a sixth-grade class were also randomly selected. The total number of 498 students (250 sixth graders and 248 fourth graders) was administered a six-item questionnaire consisting of three problems relating to control of variables and three other problems relating to combinatorial reasoning. Students performance on the questionnaire had a range of scores from 0-18, since for each answer to a problem a score 0 (totally incorrect answer) to 3 (totally correct) was assigned. Based on students' performance on the questionnaire, two different groups of students were separated. The first group included students who had a score between 4 and 7 (the low achieving students), and the second group included those students who had a score from 14-17 (the high achieving students). These cut-off scores were decided based on the total distribution of students' scores on the questionnaire. Thus, four strata of students were formed, namely, high achieving students (fourth and sixth graders), and low achieving students (fourth and sixth graders). Finally, 20 students from each stratum were randomly selected.

Individual interviews were conducted with these 80 students as they were investigating an improvised device. The device consisted of a wooden box with eight small electric lamps in a line and five switches, in another line below the lamps, which could move up and down. The lamps and the switches were connected in a "hidden" circuit inside the box, in a way that only one or none of the lamps could light on, while a "tester," or a general switch, located below the five switches, was used to test whether one or more lamps were lit on. The lamps and the switches were connected in such a way, so that only one lamp could light on with different combinations of the switches. Switch number 3 constituted the general switch of the device and switch number 5 was not connected to the electric circuit of the device at all.

When students came to the interview sessions, they were presented with a simpler device consisting of one lamp and a similar "tester." The interviewer, in a game-like fashion, explained the function of this device and the role of the switch and the tester. Then, the main device was presented and students were asked to form "initial hypotheses" about its functioning. Subsequently, they were asked to carry out experiments and test their hypotheses. The students were instructed to "think aloud," prior and after any experiment using the device. The interviewees were instructed to proceed in a step-by-step fashion and keep a record of their observations. The record of their observations was used as a type of external memory system. Each interview was tape-recorded, and transcribed for data analysis.

The data were analyzed qualitatively and quantitatively. For the quantitative analysis each interview was carefully analyzed using the constant comparative analysis approach. With this analysis each dependent variable was analyzed in different qualitatively different levels indicating a progression in performance. The lowest level of performance was assigned a score of 0 and each progressively better level of performance was assigned progressively a score of 1, 2 etc. Thus students' performance on each dependent variable was quantified, while the sum of the six dependent variables (identifying the general switch, identifying the dummy switch, lighting the lamps, combinatorial reasoning, ability to control of variables, ability to co-ordinate theory and evidence) that were considered constituted the Investigation Ability of each student.

RESULTS

Qualitative Analysis

When students came to the interview sessions they proposed their hypotheses prior to experimenting with the device ("initial hypotheses.") Table 1 presents a sample of students' initial hypotheses.

Table 3. Students' Initial Hypotheses (H_n)

Hypothesis (H_n)
H_1: Different lamps will light up when different switches are used in combination, and all lamps can light up.
H_2: Lamps will light up, one at a time, using a different switch. Only five lamps can light on.
H_3: One or more lamps can light up when only one switch is used. Multiple lamps can be simultaneously lit up.

Students proposed a variety of initial hypotheses, mainly based on their prior knowledge and observations. Only four students were able to form at least a hypothesis using their combinatorial reasoning and considering the device as system of integrated parts (H1). After a series of experiments, almost all the students modified their initial hypotheses. Nine fourth graders and 17 sixth graders identified the general switch, but only 5 of them gave it the right name. Among them, 14 students applied co-ordination of their hypotheses and collected evidence to solve the problem of the general switch and the other 12 students examined only the collected evidence and their records to solve the problem.

On the other hand, more students (18 fourth graders and 23 sixth graders) identified the "dummy" switch and 15 gave it the right name. The rest of them proposed, for example, that the "dummy" switch was more important, because "it could make the lamps light up twice." Interestingly, all the students, who solved the problem of the dummy switch, searched only the experimental space and did not search the hypothesis space. Additionally, all students managed to discover which combinations of switches could light up every lamp.

Besides, the students did not exhibit the ability to co-ordinate their hypotheses with the collected evidence. They considered that only "positive" experiments, that is, experiments where a lamp could light up, were useful for their investigation. Only 26 out of 80 students formed a hypothesis with the possibility of a negative experiment. Most of the students were inclined to mainly search the experimental space rather than the hypothesis space. Only 5 students took into consideration contradictory data and modified accordingly their hypothesis. The majority of students (68 out of the 80 students) exhibited confirmation bias, that is, they tended to test their proposed hypotheses using only experiments that could confirm their stated hypotheses, but did not use any experiments that could disconfirm them.

Students' combinatorial reasoning was examined based on the number of identical experiments and the number of the redundant experiments they performed, and their ability to move the switches up and down systematically. Obviously, some students were unable to discern patterns in their recorded observations and repeated some identical experiments (same combinations of switches). Only 13 students did not perform any identical experiment, and 21 students performed more than 3 identical experiments. The remaining 46 students performed from 1 to 3 identical experiments. They also performed redundant experiments, because of their inability to control variables or their limited combinatorial reasoning. Only 25 students were able to employ a more developed combinatorial reasoning, moving the switches up and down in a systematic way. For example, the student 6L214 (6 refers to the class, L refers to Low Achieving based on performance on the initial six-item questionnaire, and 214 is the number of the student in the initial sample of the study) performed the following experiments: 11000, 10100, 10010, 10001, 01100, 01010, 01001,00110, 00101, 00011. The five numbers represent the five switches of the device. Number 0 refers to up position and number 1 refers to down position. It is obvious, from this sequence of experiments, that the child used a developed combinatorial reasoning, because he tried to performed experiments where only two switches were at the down position and he managed to perform all the possible experiments where all the relevant combinations were used.

Students' ability to control variables was also examined. A student was considered that employed the control-of-variables strategy when in two successive experiments moved only one switch. Almost all students faced difficulties in controlling the variables, since only one student managed to apply this strategy in more than 75% of his experiments and almost all the students (68 out of 80) controlled variables in less than 50% of the performed experiments.

Based on the results, five distinct experimentation strategies were used during the investigation with the main experimental device. The five strategies are presented starting from the most simple and undeveloped strategy to the most complex and most developed strategy.

- *Strategy 1 Random search of the experimental space only.* Students who followed this strategy used a trial and error strategy by performing random experiments that did not follow from any previous hypothesis. These students were not able to solve any part of the problem.
- *Strategy 2: Systematic search of the experimental space only.* Students who used the strategy 2 performed experiments that did not refer to a specific hypothesis. On the other hand, they performed experiments while they were using systematically different combinations of switches
- *Strategy 3: Random search of the hypothesis space without the ability to solve the problem.* Students who applied strategy exhibited the ability to formulate several hypotheses by searching the hypotheses space, but were not able to verify their hypotheses based on their experimental results. Consequently, they were unable to co-ordinate hypotheses and experiments in order to solve the problem.
- *Strategy 4: Ability to solve the problem based on the experimental space and not on the co-ordination of evidence and theory.* The students who applied this strategy were able to identify general or/and dummy switch, but they did that based only on the experimental results and without coordinating evidence and hypotheses. So, they managed to solve the problem when they were prompted to carefully examine their recorded data.
- *Strategy 5: Searching the hypothesis and the experimental space. Co-ordinating theory with evidence.* Students who applied this strategy were able to solve the problem by co-ordinating their hypotheses with the experimental results. They formulated hypotheses and they modified them based on contradictory data.

Table 2 presents the number of students who followed each strategy, based on their initial abilities and their age.

Table 2. Investigation Strategies

Strategies	Frequencies				Total
	4th Grade		6th Grade		
	Low Abilities	High Abilities	Low Abilities	High Abilities	
1	8	0	5	0	13
2	3	3	10	0	16
3	7	2	3	2	14
4	2	10	2	9	23
5	0	5	0	9	14

Quantitative Analysis

Using the constant comparative analysis method, separate rubrics for evaluating the six different variables that were considered as components of students' investigation ability had been developed. The levels of each rubric were not predetermined, but emerged inductively from the analysis of the interviews. Each progressively higher level in any rubric differed from the preceding level, because it contained elements of improved effort or answer. The lowest level of each rubric indicated that students did not develop the ability that was represented by the specific variable, or that they had the lowest possible performance on that variable, and a score of 0 was assigned to this level of the rubric. Students' performance on any higher level was progressively assigned a score of 1, 2, 3 etc, respectively, since each higher level indicated a qualitatively better performance. Thus, each of the six variables was quantified by assigning progressively increasing scores for each higher level of the six different scoring rubrics relating to each of the six variables

Table 3 presents the results of the multivariance analysis MANOVA 2 (Abilities) X 2 (Grade) with depended variables the six variables that were considered as components of students' Investigation Ability.

Table 3

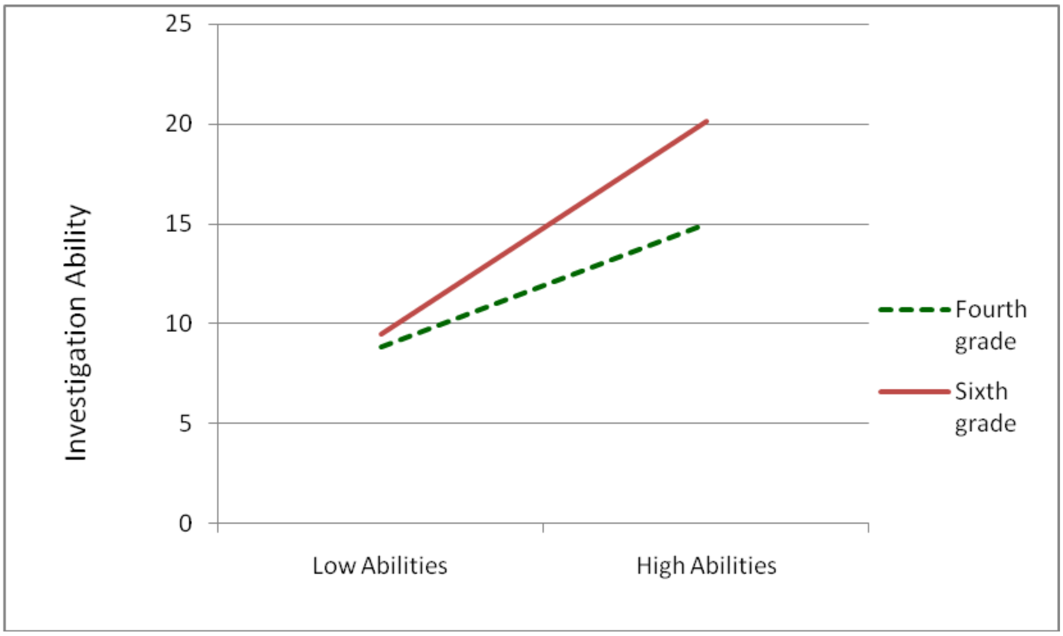
In depended variable	Depended Variable	F	P value
ABILITIES	General Switch	9.609	0.003*
	Dummy Switch	1.898	0.172
	Lighting of Lamps	0.409	0.525
	Control of Variables	0.336	0.564
	Combinatorial Reasoning	0.727	0.396
	Co-ordinate th. And evid.	9.828	0.002*
	Investigation Ability	9.096	0.003*
GRADE	General Switch	46.051	0.001*
	Dummy Switch	56.803	0.001*
	Lighting of Lamps	1.634	0.205
	Control of Variables	0.084	0.773
	Combinatorial Reasoning	39.111	0.001*
	Co-ordinate th. And evid.	33.433	0.001*
	Investigation Ability	79.018	0.001*
ABILITIES X GRADE	General Switch	0.795	0.011*
	Dummy Switch	0.001	0.376
	Lighting of Lamps	0.001	1.000
	Control of Variables	0.020	1.000
	Combinatorial Reasoning	11.652	0.887
	Co-ordinate th. and evid.	5.669	0.001*
	Investigation Ability	0.795	0.020*

Note: * shows the statistically important results.

The results of MANOVA Analysis showed that there were statistically significant differences between high and low ability students for the variables "General Switch" [F (1, 80)= 46.051, $p.$=0.001], "Dummy switch" [F (1, 80)=56.803, $p.$=0.001], "Combinatorial reasoning" [F (1, 80)=39.111, $p.$=0.001], "Co-ordinate theory and evidence" [F (1, 80)=33.433, $p.$=0.001] and "Investigation Ability" [F (1, 80)=79.018, $p.$=0.001], where high ability students performed better than low ability students. Statistically significant differences between fourth and sixth graders were also identified for the variables "General switch" [F (1,80)=9.609. p=0.003], "Co-ordinate theory and evidence" [F (1, 80) =9.828. $p.$=0.002] and "Investigation Ability" [F (1, 80) =9.096. $p.$=0.003], where sixth graders performed better than fourth graders.

Table 3 also shows that the interaction effect between abilities and grade was statistically significant for the variables “General switch,” “Co-ordinate theory and evidence” and “Investigation Ability,” where sixth graders with high abilities performed better than fourth graders with high abilities (General switch: t=-3,49 and $p.$=0.001, Co-ordinate theory and evidence t=-4.43 and $p.$=0.001 and Investigation ability t=-4.013 and $p.$=0.001). On the other hand, the differences between sixth graders with low abilities and fourth graders with low abilities were not statistically significant. The nature of the interaction effect between abilities and grades in terms of students’ Investigation Ability is clearly understood from Figure 1. As indicated in Figure 1, the difference between fourth- and sixth-grade students’ Investigation Ability becomes larger for high ability, although this difference is less for low ability students.

Figure 1. The Interaction Effect between Students’ Grade Level and Their Abilities in Terms of their Investigation Ability



CONCLUSIONS AND IMPLICATIONS

The results of the study showed that among the students who were characterized as high ability students based on their performance on the initial six-item questionnaire there were more sixth-grade students than fourth-grade students, who had successfully identified the general and the “dummy” switch, while only few low ability students from both grades were able to do so. Even the students who had successfully identified the functioning of the main device, they could not be considered as “good solvers,” because they performed identical experiments, did not effectively apply the “control-of-variables” ability, and did not take full advantage of their external memory system (recorded data). The students in general did not exhibit advanced ability to coordinate their hypotheses (theory) with evidence, they were usually performing random experiments in the experimental space, and only few of them conducted experiments for testing previously stated hypotheses.

More specifically, the majority of the students failed to employ the control-of-variables strategy, but they were, to a certain extent, able to employ an immature and not fully developed combinatorial reasoning. When a student has well developed his/her combinational reasoning, then he/she will be able to combine the switches and to determine the total number of different experiments that can be performed with the specific device, or they will be able to exactly define the experimental space. Similarly, after identifying the general switch or the “dummy” switch, they will be also able to correctly conceptualize that the experimental space is accordingly reduced. In such a case, students will avoid conducting unnecessary experiments.

The statistical analysis of the quantified data indicated that the students who participated in the present study did not adequately develop their Investigation Ability (IA). IA was a compound variable consisting of several component variables. The component variables “Co-ordination of theory and evidence” and “Control of Variables” were less developed, while students appeared to have developed to a certain their combinatorial reasoning. Moreover, there were significant differences between high and low achievers, as they were characterized based on their performance on the initial six-item questionnaire. There were also significant differences between fourth- and sixth-grade students, although they were matched in terms of their performance on the initial questionnaire. These differences clearly indicate that other factors beyond the abilities of controlling variables and combinatorial reasoning contribute to students’ investigation ability. The significant interaction effect between grade and abilities in terms of students’ investigation ability indicates that the existing gap between high and low achievers becomes bigger as students become older. This effect seems to indicate that the existing educational system is tailored only to the needs of students that are at a higher stage of cognitive development, and does not address the needs of the diverse student population.

The study clearly suggests that the existing curricula and the dominant teaching practices are far from achieving the declared objectives of science teaching at the primary school. Similar research designs can be very useful in identifying patterns of students’ cognitive development and design of teaching scenarios conducive to accelerating their cognitive growth. Future research should focus on inquiry-based activities that seem promising in our attempts to improve teaching and learning in the primary school classrooms and beyond.

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DEVELOPMENT AND APPLICATION OF LEARNING MATERIALS FOR SCIENTIFIC CREATIVITY AND ANALYSIS OF STUDENTS' RESPONSES ABOUT IT[18]

Jongwon Park

Chonnam National University, Gwangju, 500-757, Korea

jwpark94@chonnam.ac.kr

ABSTRACT

Nowadays, secondary school curriculum and educators have emphasized the creativity in school learning. Especially, there are growing evidences suggesting that creativity is domain specific. Few years ago, I developed a model of scientific creativity consisting of three axes; creative thinking, scientific knowledge, and scientific inquiry skills. Now, using this model, concrete learning materials for scientific creativity have been developed and applied to students in the 'center for the gifted in science' established in my university. As a result, it was observed that many students responded positively about the developed learning materials, especially, they answered that it was helpful for their creative thinking, and therefore, they wanted to lean this kind of materials in the future activity. In these learning materials, specific guides were included to encourage students' creativity activities. From the analysis of students' activities, it was also found that these guides could improve their divergent thinking which was a kind of creative thinking.

Keywords: *scientific creativity, teaching model, teaching strategy, students' responses*

INTRODUCTION

Creativity is domain-specific. That is, creativity in science may have different aspects compared to creativity in art or in literature. Gardner's theory of multiple intelligences (1983) also implicates that a creative scientist requires high level of logical-mathematical and naturalist intelligence while a creative politician requires strong linguistic and interpersonal intelligences (Solomon et al., 1999). This article starts from the model of scientific creativity (MSC) with the following three premises (Park, 2004):

(1) MSC should cover various thinking skills needed to perform or carry out scientific activities, such as divergent thinking, convergent thinking, and associational thinking.
(2) Creativity is content-dependent, so MSC should include scientific knowledge contents.
(3) Scientific creativity deserves to be manifested in the process of scientific inquiry, so MSC should reflect the model of scientific inquiry, and include scientific inquiry skills.

According to MSC, if someone invents a new experimental technique while designing an experiment (scientific inquiry skill) related to Faraday's law (scientific knowledge content) by thinking divergently (creative thinking), it is said that his/her new experimental technique is invented by virtue of scientific creativity. Or, if someone finds novel regularities by convergent thinking (thinking) in the process of analyzing experimental data (scientific inquiry skill)

[18] This is written based on Park(2004)'s article titled "A suggestion of cognitive model of scientific creativity" published in Journal of Korean Association of Science Education, 24(2), 375-86.

related to Ohm's law (scientific knowledge contents), his/her finding of new regularities can be viewed as being the product of scientific creativity.

From now on, I will describe the main characteristics of three creative thinking (divergent, convergent, and associational thinking), and discuss how creative thinking should be linked with scientific knowledge and scientific inquiry.

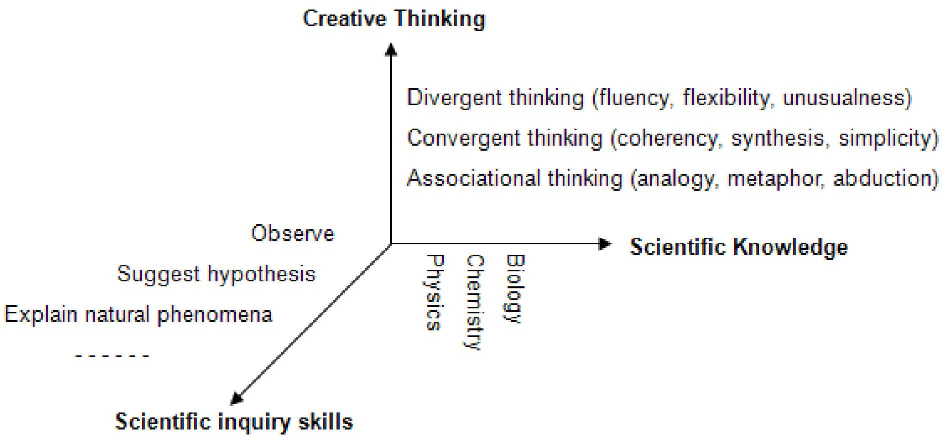


Figure 1. The model of Scientific Creativity (MSC)

DESCRIPTION OF THE MODEL OF SCIENTIFIC CREATIVITY

Divergent Thinking

Divergent thinking can be characterized by fluency and flexibility which are well defined as the ability to produce numerous and diverse ideas (Guilford, 1968; Runco, 1991). For example, if we ask someone to suggest ideas about the alternative use of a compact disc instead of listening music, the number of ideas generated corresponds to fluency and the number of categories of ideas corresponds to flexibility.

Here, I assumed that unusualness can be the third feature of divergent thinking. Unusual thinking is defined as seeing, thinking, and acting differently from previous and traditional views, ideas, and custom. The reason unusual thinking is involved as the third feature of divergent thinking is because there have been many instances in the history of science in which unusual thinking leaded to a paradigm shift in science or a new scientific discovery.

For example, when Kepler changed conventional belief that the orbits of planets were circular into the idea of elliptical orbits, when Dirac named the particle with negative energy being neglected by most scientists at that time an "antiparticle", when Einstein rejected the presence of "ether" which was assumed by almost all scientists as a medium of electromagnetic wave, the common characteristic of their thoughts was unusualness.

Therefore, Root-Bernstein (1999) notes that creative scientists enjoy playing mental games, such as 'what if', by doubting basic premises or by changing conventional definition. For instance, questions such as, "If the energy is not conserved?", "If we redefine the electric current as 'i=dq/dt' to 'i=dt/dq' ?", or "If the speed of light is decreased to 10km/s?" may be used to encourage unusual thinking among students.

Convergent Thinking

> "Now it is clear that creative work often requires critical and convergent thinking as well as divergent thinking." (Runco, 1999, pp. 449-450).

While divergent thinking corresponds to widening and spreading out thoughts, convergent thinking corresponds to collecting and structuring various thoughts. Here, I characterize convergent thinking as having following three features: coherence, synthesis, and simplicity.

Recognition of the presence of incoherence can play a significant heuristic role because it may lead to the discovery of new ideas and revision of previous models by virtue of an effort to eliminate incoherence (Nersessian, 2002). Thagard (1997) also insists that when coherence fails, the potentially more cognitive processes are triggered and, as a result, this incoherence can lead to new discovery. For instance, Einstein's special relativity was initiated from the following thought experiment conducted at 16 years of age: what would be the consequences of running alongside a light wave? If a light wave is seen as being static (according to Galileo' relativity theory), then is it also a wave? (electric and magnetic field of a light wave should vary with time according to Maxwell's theory). Park and Jang (2005) also observed that one of major three motives of physicists' research was recognition of conflict (Table 1).

Table 1. Research motives of actual physicists

M1: Incompleteness	
	M11: Inaccuracy of experiments
	M12: Unidentified/undeveloped areas
	M13: Unproven parts of the theory
M2: Discovery and Development	
	M21: Discovery of new data/phenomena
	M22: Suggestion of a new theory
	M23: Development of new materials
	M24: Development of new experimental techniques/equipment
M3: Conflict	
	M31: Mismatches between theory and experiment (unexplained phenomena)
	M32: Internal conflicts inside the theory

The level of synthesis depends on the number of concepts or ideas in constructing a structured system. In the history of science, we can see that scientific knowledge have developed with increasing the level of synthesis. For instance, electricity and magnetism were not connected with each other at first, however, after Ampere discovered a magnetic field around an electric wire flowing electric current, the two were interlinked. And by combining Ampere's law, Faraday's law, and Gauss's law into Maxwell's electromagnetic theory, electricity and magnetism were completely unified. Based on the fact that the speed of electromagnetic wave derived from Maxwell's theory was the same as the speed of light, electromagnetic wave was regarded as being the same as light. And by Einstein's photoelectric effect, wave was combined with particle.

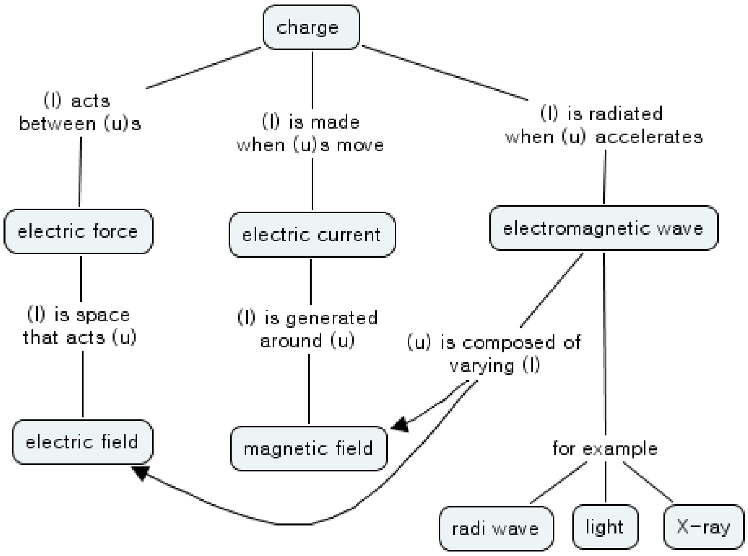


Figure 2. Concept map about electricity and magnetism.
Here, (u) means upper concept, and (l) means lower concept

To encourage synthetic thinking for students, Concept Maps™ (Novak & Gowin, 1984) emphasizing the meaningful relationship between concepts by connecting them using linking words can be useful (see Figure 2).

Although many ideas or concepts are collected together, the total structure needs to be simple. Therefore, many scientists have mentioned simplicity as a category for a good theory or solution as follows:

> "… he (Einstein) got the idea of connecting gravitation with the curvature of space. He was able to develop a mathematical scheme incorporating this idea. … The result of such a procedure is a theory of great simplicity and elegance in its basic ideas." (Dirac, 1979, p.92)

Associational Thinking

New ideas cannot be derived from nothing. They are invented by connecting it with extant ideas or borrowing other well-known ideas to understand new phenomena. Associational thinking plays an important role in discovering new ideas from other ideas. There are two types of associational thinking: Similarity-based thinking and Non-similarity-based thinking.

Analogy, metaphor, and abduction are involved in similarity-based thinking (Park, 2006). Mumford and Porter (1999) stress that analogical reasoning is one of the key components of creative thought, and define it as a map of similarity between two or more phenomena. Holyoak and Thagard (1999) note that among the four distinguishable uses of scientific analogy - discovery, development, evaluation, and exposition - the most exciting use of it is when a new hypothesis is discovered. They suggest several typical examples of analogy, such as Darwin's animal and plant competition-human population growth, Maxwell's electromagnetic force-continuum mechanics, and Kekule's benzene-snake dream. While they studied the role of analogy on theory construction based on the historical cases, Dunbar (1997) observed the real work of scientists in molecular biology laboratories for a long period, and found that creative scientists used various analogies very frequently and creatively when formulating a new hypothesis.

Metaphors have also been emphasized as a fundamental tool in creative thinking. For instance, Miller (1996) describes how metaphors are used as a means to invent new knowledge in terms of established knowledge for great scientists such as Einstein, Fermi, Heisenberg, Maxwell, Salam, Weinberg, and Yukagwa

Peirce (1955) argues that even though the process of creating a new hypothesis involves a psychological factor, it can also be viewed as a rational process. He says, "All the ideas of science come to it by the way of abduction. Abduction consists in studying facts and devising a theory to explain them" (Peirce, 1998, p. 205). Hanson (1961) also insists that guessing new idea comes not from induction or deduction, but from abduction which "involves sensing ways in which the current situation is somehow similar (analogous) to other known situations and using this similarity as a source of hypotheses in the present situation" (quoted in Lawson, 1995, p.7).

Park (2006) observed, based on the analysis of students' processes of explaining new phenomena which conflicted with their prior prediction, that students used similarity-based reasoning between the new phenomena to be explained and background knowledge which they already knew. Figure 3 indicates steps of generating new ideas using similarity-based reasoning.

> New Phenomena (NP) has properties α, β, and γ.
> Background Knowledge (BK) also has similar properties α', β', and γ'.
> Then, the NP and BK share similar properties with each other.
> And the BK has another property δ'.
> Therefore, it is worth inferring that NP will also have property δ,
> even though δ has not yet been confirmed.

Figure 3. The model of similarity-based reasoning

To encourage similarity-based reasoning with physics contents, the following questions can be useful: "Find similar properties between Faraday's Law and Hooks' Law as many as possible." The, for this question, students can answer that (1) both try to go back to their original state, or (2) two laws are about electromagnetic phenomena because restoring force in Hook's law is generated by electric attraction between molecules.

Not types of all associational thinking are based on similarity. Connecting or combining two ideas, even though they are not shown as sharing any similar properties with each other, can also lead to new ideas or novel products. For example, combining a wine glass with a liquid crystal thermometer can make a new wine glass indicating the proper temperature at which to drink wine, and "radio glasses" can be made by inserting a mini radio into a pair of ordinary eyeglasses with earphones connected to the glasses. In fact this, type of thinking is useful strategy for invention of new items in commercial situation.

Others: originality, value, and elaboration

If someone invents new powerful weapons, his/her activity cannot be regarded as a scientific creativity activity because it is not valuable for mankind.

> "… we shall define creative scientists as those whose work is considered high in both originality and value by other scientists in the same field." (Mansfield & Busse, 1981, p.3)

Elaboration is also another condition for good scientific creativity activities. Many scientific ideas were not discovered as a completed form but evolved and developed through successive articulation and refinement from the initial format of an idea. For instance, the initial atom model suggested by Bohr in 1913 had various shortcomings that could not be solved at that time. But the initial model was articulated and refined by regarding the nucleus as being composed of proton and neutron, by assuming that the nucleus moved around the center of mass, by modifying the circular orbit of the electrons into elliptical orbit in 1915, and by considering the relativistic effect of mass of the moving electron. The reason why electrons did not radiate electromagnetic wave during movement in the specific orbits around the nucleus could be solved later when De Broige's concept of "matter wave" was invented in 1925.

Role of scientific knowledge and scientific inquiry in Scientific Creativity

> "However, thinking alone will not lead to creative excellence, since creativity does not occur in a vacuum but in a particular field." (Cropley & Urban, 2000, p. 485-498).

Scientific creativity can be actualized by linking the previously mentioned three types of thinking with concrete scientific knowledge contents. In fact, Weisberg (1986) stated that creative persons had more professional knowledge compared to less-creative persons, and Wolpert (1992) pointed out that scientific intuition leading to new discovery related not to common-sense experience but to the highly specified knowledge (Wolpert, 1992, p. 64). These notes relate to Hempel's explanation about generating new scientific hypotheses. "Scientific (new) hypotheses are not *derived* from observed facts, but *invented* in order to account for them. … The inventive effort required in scientific research will benefit from a through familiarity with current knowledge in the field." (Hempel, 1965, p.15)

However, it is worth noting that background knowledge may obstruct the generation of new ideas. That is, background knowledge can narrow thinking and restrict it to the conventional (Cropley, 1999). This is also similar to the influence of existing well-established paradigm on the evaluation of empirical data or views conflicting with it. Kuhn (1977) found that scientists often fail to reject existing paradigms when faced with anomalies or counter-instances. This is because background knowledge usually has a lot of supporting evidences and so it is not easy to be doubted. Therefore, even though background knowledge is important to create new ideas, every inventor needs to go back to the state of novice minds.

> "In the absence of appropriate personal properties such as 'openness to the spark of inspiration,' flexibility, or courage to try the new, great expertise can inhibit the production of novelty. In order to achieve effective surprise, experts need to be capable of seeing the contents of their field in a fresh light. Creative experts often show a freshness and openness that is more typical of beginners; this has been referred to as the 'novice effect.'" (Cropley, 1999, p. 516)

In order to understand when creative thinking is necessary in the process of the scientific inquiry, we need to know the detailed processes of actual scientists' research procedure. Figure 4 indicates the actual physicists' scientific inquiry processes from from motives of research to the results of it (Park, Jang, and Kim, 2009).

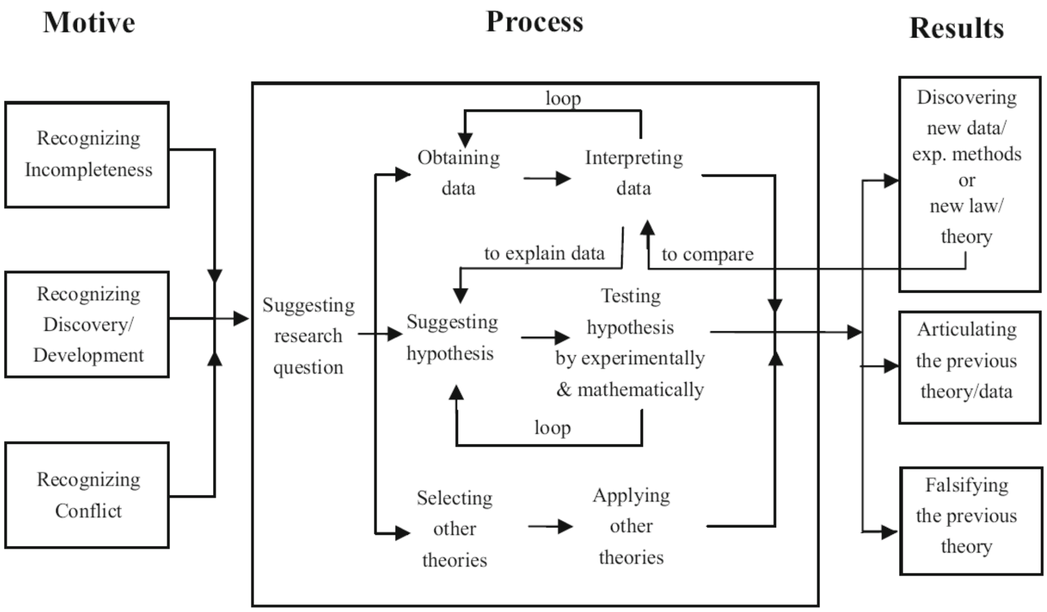


Figure 4. Scientific Inquiry Process

Here, important point is that scientific creativity should be actualized at a certain point of the process of scientific inquiry. For instance, when *obtaining and interpreting data,* scientific creativity can lead to the discovery of new features or hidden novel regularities. Or when *designing experiments to test scientific hypotheses*, scientist may invent new method required to obtain important data through scientific creativity.

STEPS FOR LEARNING SCIENTIFIC CREATIVITY

To teach scientific creativity, Park, Park, & Lee (unbublished) suggested learning model consisting of three steps: Activity spontaneously, Guides for creative thinking, Activity Again (see Figure 5).

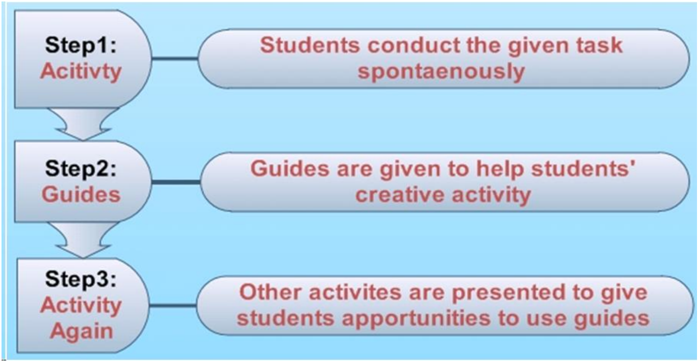
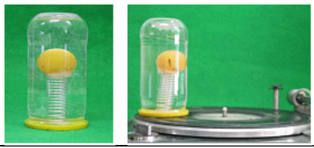


Figure 5. AGA^2 model for scientific creativity activity

In the first step (Activity spontaneously), students are provided task to be solved, such as ‘revise the presented ordinary electroscope for more diverse usage’, ‘suggest various new scientific hypotheses to explain the observed phenomena’, or ‘suggest new and interesting situations which may show unusual phenomena’ as shown in Figure 6.

In the first step, students solve the tasks by themselves, that is, there is no any hints, guides, or aids for helping students’ solving activity. Therefore, some students can show high level of creativity by solving the tasks successfully, however, many others may solve the tasks in the level of common senses or in conventional ways, and also, some students may conflict difficulties in solving the tasks.

Ping-pong ball is connected by spring and inserted into transparent bottle with water. If it is placed on the rotating table, then you can see that the ball moves into inward direction which is different from usual situation.



1. Likewise, find out any other interesting situations which can show unusual results.
2. Explain the results why such unusual results are happened.

Figure 6. Activity in the first step of AGA^2 model

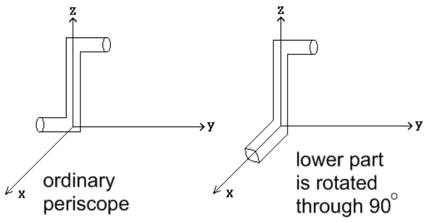
Therefore, in the second step, we provided actual guides which could encourage students' creative activity. In Figure 7, four basic guides are provided to help students suggest new unusual situations. Of course, these guides are not general rules for all types of scientific creativity but may be different according to the tasks. However, basic ideas of guides are closely related to creativity thinking in MSC. For instance, three guides provided in Figure 7 are basically to encourage 'unusualness' which is one component of divergent thinking. That is, in these guides, to encourage students to think unusually, they are guided to change ordinary structure or the assumed conditions, and to think reversely.

To find out unusual situations and to explain it, following guides can help you.

Guide 1: You can change basic structure. For instance, you can rotate the lower part of periscope as figure:

(1) Describe and explain what you observe using 'strange periscope'.

(2) Find out any other unusual phenomena by changing basic structure of ordinary periscope.



Guide 2: Now, you can also change the assumed conditions involved in the usual situation. For instance, when calculating the falling speed, we usually assumed that there is no air resistance. Then, you can think about the falling object in the air.

(1) Predict what will happen when air resistance acts on falling objects.

(2) Find out any other unusual phenomena by changing the assumed conditions in the falling object.

Guide 3: Finally, reverse thinking can also help you find unusual phenomena. For instance, usually convex lens made by glass is placed in the air. Then you can think convex lens made by air inside the glass.

(1) Describe and explain what you observe using 'air convex lens'.

(2) Find out any other unusual phenomena by thinking reversely in ordinary convex lens.

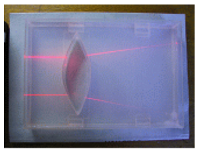


Figure 7. Activity in the second step of AGA^2 model

The final step is to apply the guides exercised in the second step to other new situations. In Figure 8, students are encouraged to apply the guides in finding out unusual phenomena using usual electroscope.

Now, find out any unusual situations in the usual electroscope by applying above 3 guidelines.

Figure 8. Activity in the third step of AGA^2 model

STUDENTS' RESPONSES ABOUT THE WORKSHEETS FOR SCIENTIFIC CREATIVITY

Recently, Park, Park, and Lee (unpublished) developed about 30 learning materials for scientific creativity based on AGA^2 model. These materials were classified into three categories: thinking creatively in scientific context, conducting scientific inquiry creatively, and understanding/applying scientific knowledge in creative ways. In the ‘Center for the gifted in Science’ in my university, I have applied the learning materials to the gifted students for several years and analyzed their responses to obtain the information about whether they enjoyed the scientific creativity activities, there were any difficulties in conducting the activities, the provided guides in the second step were affective for their creative activities, and so on.

Now, many data have accumulated and other research colleagues with me analyzed the data in different ways, but all analysis is not completed yet. Therefore, here, I would like to show some examples of results briefly. It is worth mentioning that some results examples are under more detailed analysis.

(1) Learning material shown in Figure 6 ~ 8 was used for nine students (7~8 grade, 13~14 years old) in ‘Center for the Gifted in Science’ (Park and Jee, unpublished). The second step and the third step activities were presented after completing the first step activity. It took about three hours to complete all three steps. From the analysis of students’ responses using the 5 Likert scale (5 point means highly agree, 3 means neutral response, 1 means highly disagree) questionnaire after the activity, students answered that even though the activities were not easy to them (average response was 2.4), it was interesting to them (4.0), it was helpful for them to understand scientific knowledge (3.6), and it could improve their creative thinking (4.0). As a result, they answered that they wanted to conduct this kind of activity in the future course (4.3).

(2) In the study by Park (unpublished), fourteen students of 7 and 8 grades were asked to generate various new scientific inquiry problems valuable to be investigated (Figure 9 is the first step of learning activities for generating scientific inquiry problems).

Two ring magnets are put into the plastic rod as shown in the photo. Because of repulsive force between two magnets, upper magnet is floating into the air.

After observing the phenomena, suggest various problems (questions) valuable to be inquired, as many and precisely as possible.

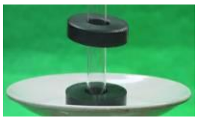


Figure 9. Problem situation used in activity

In this study, I analyzed how many and various inquiry problems were generated before the guides in the second step and after the guides.

As a result, in the first step, total number of inquiry problems (IPs) spontaneously suggested by students was 86 (average 6.1 per one person). However, in the second step in which guides for creative thinking were provided, the students suggested more 78 IPs (average 5.3 per one person) additionally. This means that the number of IPs suggested by the students increased by 91% (=78÷86 × 100). Comparing the total number of IPs with the initial number of IPs before the guides in the second step, the incensement is statically significant (t=7.4, p<.01). This means that guides in the second step could help students’ fluency (the number of ideas) which was feature of divergent thinking.

And we compared IP types before and after the guides for each student to check whether the number of IP types will be increased by guides. As a result, I found that total number of IP types was average 2.5 in the first step, but, it increased to 3.6 in the second step. That is, the number of IP types increased by 44% (=(3.6-2.5)÷2.5 × 100), and the difference of number of IP types between the first step and the second step was statistically significant (t=3.4, p<.01). This means that guides in the second step could help students' flexibility (various ideas) which was also feature of divergent thinking.

CONLCUSION

In this article, based on the assumption that scientific creativity may have different features compared to creativity in other areas such as literature or art and so on, the model of scientific creativity (MSC) is suggested. Of course, to understand the scientific creativity more completely, the role of personal characteristics such as openness, autonomy, or self-confidence and so on, the role of social, environmental, or educational supports, and/or the role of intrinsic/extrinsic motivation should be discussed more widely. Therefore, in the future research, other various and important aspects can be added to the MSC suggested in this article.

And also, theoretical model should be verified and applicable in various contexts. To do this, concrete many scientific creativity activities also were developed and applied to the gifted students in science. Here, I showed some examples of results about students' responses of the developed activities. In the near future, I hope that more detailed results about the effects of the developed activities on improving students' scientific creativity will be presented.

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HOW KINDERGARTEN CHILDREN CAN USE TOYS TO EXPLORE SCIENCE AND TECHNOLOGY CONCEPTS

Sara Joana Pereira

Universidade de Aveiro – Centro de Investigação Didáctica e Tecnologia na Formação de Formadores

sjpereira@ua.pt

Isabel P. Martins

Universidade de Aveiro – Centro de Investigação Didáctica e Tecnologia na Formação de Formadores

imartins@ua.pt

ABSTRACT

The aim of this paper is to present a science teaching strategy integrated in a wider project to develop, in Portugal, a kindergarten science curriculum with a Science-Technology-Society focus. Besides establishing the adequate science contents, process skills and scientific attitudes, it will develop a set of articulated practical activities (teaching, learning and assessment strategies) as well as the respective didactic resources (teacher's guide & materials).

At the present stage of the project ten different practical activities, regarding several science concepts, were designed. They were all validated in real-context by Kindergarten teachers who attended an in-service training program designed with the purpose of developing the necessary subject matter and pedagogical knowledge to support these educational practices.

Detailed presentation of one of these science teaching strategies (aims, guide, resources and assessment), will be made, as well as of its validation process and conclusions.

"Granny's toys and mine" is a context-based teaching strategy intended to engage kindergarten children (3-6 years old) in exploring concepts regarding the presence of science and technology in our daily lives, namely in toys. While placing a variety of toys in two different points of a given time line according to underlying criteria, children also construct upon prior knowledge to recognize the consequences of the evolution of science and technology.

Data from the validation process indicates that throughout the activity children demonstrated a functional understanding of some scientific inquiry processes as well as of related science concepts.

Keywords: *Science Education; Science in Kindergarten; Teaching and learning strategies; Competences development; Scientific and technologic literacy.*

INTRODUCTION

The research community today shares the understanding that scientific and technological literacy should have an early start, as soon as in kindergarten, in a child-centered approach and in a socio-constructivist environment. This approach allows children to progress from a descriptive level of the natural phenomena they observe in their daily lives to an explanation level, and from personal and 'small' ideas to shared and 'big' ideas (Harlen & Qualter, 2004).

The reasons for early science education have been presented by a vast number of researchers (Harlen, 2006; Heshach, 2006; Keogh & Naylor, 1999; Charpak, 1996) arguing that it does undoubtedly contribute to scientific literacy. Moreover, science education can even be regarded as a right for everyone (Fumagalli, 1998), included in the right for education.

As far as scientific literacy is concerned, the STS (Science-Technology-Society) strands of the science curriculum have been regarded as the best way for school science to face the challenges of 21st century society (Acevedo-Diaz et al., 2003; Aikenhead, 2002; Membiela, 2001). Science and technology should be taught embedded in social contexts which are relevant to students, displacing its focus from concepts. School science should allow children to construct an authentic image about science and technology, about the way scientists work and about the role that science and technology play in the evolution of Humanity. Students should be prepared to critically interact with an increasingly demanding world, where social and ethical values should be considered when deciding and acting (both individually and collectively) on its problems and demands.

STS is therefore assumed as a strand that promotes students motivation both on science and on school science (Caamaño e Martins, 2005) developing positive attitudes towards science and science teaching.

At kindergarten level the emphasis should be placed on context based teaching, assuming it as a teaching setting where children can start simple interactions with scientific and technological issues, while engaged in sound, but nonetheless ludic teaching strategies.

Kindergarten children have shown to be very competent in science when quality education in this field is provided, as detailed by authors such as Saracho & Spodek (2008), Van Hook & Husiak-Clark (2008), Havu-Nuutinen (2005) and Hadzigeorgiou and others (2009). Learning activities should sustain and promote children's curiosity and enjoyment so that they develop a lasting interest in science.

Enquiring children who are led to explore the world in a scientific way are most likely to be science literate citizens who see science and technology in a positive way, understanding and making the most of its strengths and limitations. This will contribute to their understanding of the role played by science and technology in modern society, and how to use them critically to make society evolve in a sustainable way, based on human, cultural and social values.

Emphasizing the scientific and technological strain of modern society, the research community agrees on the need of science and technology literate citizens. The educational system must therefore give an adequate response to this global challenge, investing at the teacher, the curriculum and the resources levels (Eurydice, 2006).

Kindergarten curriculum must necessarily include a strong, consistent scientific dimension within a child-centered approach, such as Osborne & Dillon (2008) defend in their report to the Nuffield Foundation. It should promote the development of children's scientific ideas in a constructivist learning environment that fosters scientific and technological literacy, emphasizing science in the curriculum.

The current project was developed on a design-based research approach (Wang & Hannafin, 2005), as it identified authentic shortcomings of the educational system and associated them with subsequent actions to improve the status quo.

PROJECT RELEVANCE AND DESCRITPTION

Science curriculum in kindergarten is determined by the complementary influence of the three main axis of education in general: the *Kindergarten Teacher* (and his underlying education process), the *curriculum* and the *resources* available to implement such a curriculum. It is therefore understood that solid subject content and pedagogical knowledge are required of the kindergarten teacher (KT) to support the construction of the science curriculum he/she intends to develop with his/her class, fully supported by a range of teaching strategies.

National Portuguese Curricular Guidelines for KTs date back to a decade ago and since then an increased awareness of the role of early science teaching has taken place.

It is the overall purpose of the wider project to present a science curriculum based on the assumption that, in kindergarten, children must take an active part in learning situations that support both the investigative (skills and attitudes) and knowledge-based aspects (concepts) of science education.

To support such a curriculum, ten practical activities were developed, leading to the exploration of several concepts relating to *Materials and objects*, *Light, Force & motion* and *Living things*. They are all varied in their typology, in the didactic resources they require, their duration and intend to develop a wide range of specific and transversal competences while laying the foundations for a growing understanding of basic scientific concepts. Enquiry is regarded as a form of content and as a way to teach (Yager, 2009), focusing on children's understanding and requiring their scientific knowledge and enquiry processes.

KT is the mediator between the children and the resources, conditioning the learning and development outcomes. A specific teacher training program was developed with the purpose of empowering them with the ability to maximize the expected results.

Assessment to be made of the adequacy of the activity is to take into account data gathered from the developed teacher training program, in order to fully relate and understand all the implications. It is also to consider the input given by these KTs, which will contribute to better their potentiality as a means to innovate kindergarten science teaching.

The whole implementation process is to be repeated, in an interactive, iterative and flexible research process, with KTs who will not attend a specific teacher training program. This will allow for establishing their potential in sustaining the development of children's scientific competences, regardless of KTs specific training.

RESEARCH METHODOLOGY

In this paper a practical activity relating to the topic of materials, objects and technology, entitled "*Granny's toys and mine*" is detailed, along with the implementation process which led to its validation.

Activity description

"*Granny's toys and mine*" is a sorting activity, in which children are challenged to group different toys according to their views on the epoch they were built. Children are expected to build on prior scientific understanding, evolving to more precise ideas about the core concepts involved and the intertwined nature of both science and technology.

Competences development
This activity aims at the development of a wide range of scientific competences, as described by the examples presented.

- *Content knowledge*: (i) The diversity of materials available of natural and non-natural origin, (ii) the presence of growingly complex equipment and (iii) science and technology together allow for a growing diversity of materials and more sophisticated technology in toys.
- *Skills*: like observing, comparing, identifying differences and similarities, describing events and observations, inferring, interpreting information, questioning, thinking critically, notice change, communicate, evaluate and select information, construct argumentation, make decisions and work autonomously.
- *Attitudes:* like curiosity, showing interest in understanding the world, questioning daily events, considering ideas and opinions from others, willingness to consider evidence and to change ideas, perseverance and working cooperatively.

Teachers guide
Each teaching strategy comprises a teacher's guide, which presents and describes their objectives, the related concepts and the teaching, learning and assessment strategies. All are flexible, as far as their framework is concerned, allowing the KT to adjust aspects of its methodology to its own group of children, and presenting the following components:

Concepts – Allowing the KT to know which are used to explain the phenomenon;
Key-words – Those related to what they will observe and explore (*materials, natural materials, old, new, recent, modern, evolution, technology, science, mechanism* …);
Learning outcomes - Those expected to be accomplished at the end of the activity.
Didactic resources - Presenting what is needed to implement the activity;
Context-strategy - Describing the resources and respective activity. This intends to, on one hand, ascertain about the children's ideas on the subject and discuss them, and, on the other hand, set off their curiosity, contributing to a more motivated participation;
Framework - Presented as a flexible frame to explore the concepts with the children;
Questions – Allowing the KT to understand how he/she can stimulate children's thought and help them progress in their ideas;
Systematization – A phase at the end of the activity, intended to clearly organize the learning outcomes, and establish relations with other daily events.
Assessment strategy - Describing the resources and respective activity, along with the evidence the KT should look for in order to ascertain about children's mobilization and development of scientific attitudes and science process skills, as well of their understanding of the related scientific concepts.
Further activities – Some are presented, allowing the KT to consider related teaching strategies, as extension activities.
Communication – Is considered important while leading children to communicate to others (colleagues, classes, parents…) what they did and what they have learned;
Research – Is also recommended as a means to gather more information on the subject.

Teaching resources
The teacher's guide is accompanied by a pack of **didactic resources** which includes all the resources the KT needs in order to develop the activity with the children.

As a **context-strategy** (**Figure 1**), the pack includes a short movie made from different clips easily accessed through the internet. These depict scenes from the daily lives in the early 20th century (cooking, washing, transport, communication, etc) edited from old movies and even present-day cartoons. These scenes are easily associated with the children's grandparents, who most probably led lives like the ones portrayed in the movie.

For the development of the **practical activity**, the resource pack includes a set of 27 different toys (**Figure 2**), such as dolls, cars, balls, puppets, yo-yos and others. These can be placed into two separate groups, considering the underlying criteria: *material nature* and *attached technology*. After freely exploring the set of toys, children will classify them accordingly, debating their choices and rectifying them when required.

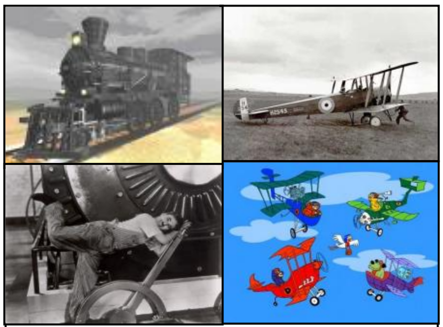

Figure 1 – Images from the context activity.

Figure 2 – The resource pack.

The toys that could have belonged to children's grandparents (**Figure 3**) are mostly Portuguese traditional toys, made of natural materials such as wood, raffia, leather, clay, and fabrics (like cotton, wool and silk) and also of metals (like lead, tin and iron). The more recent ones (**Figure 4**) can include materials of non-natural origin, such as plastic, rubber, silicone and synthetic fibres (like nylon, polyester).

Figure 3 – The set of "old" toys.

Figure 4 – The set of "new" toys.

The toys can also be sorted out by epoch according to their attached technology: the older ones' main purpose was to be set in motion by the child's application of a mechanical force (pushes and pulls resulting in slides, rolls, bounces…) whereas the most recent ones may also resort to magnetism, batteries or solar energy to cause movements, sounds, lights, etc. Implicit in all this is the fact that the most recent toys allow for a more complex interactivity with the child.

As an **assessment strategy** at the end of the activity, children are asked to match a two-by-two pieces puzzle (**Figure 5**), corresponding to sets of images showing the same object or structure built in two different periods of time (telephones, televisions, bridges, pens, lamps…). To do so, they are led to establish relationships between what was discussed up until this point and the images in the puzzles, transferring whatever knowledge they were able to construct.

Figure 5 – Puzzle for learning assessment.

Teacher training program

The developed teacher training program was entitled *STS education in kindergarten – Importance of experimental work*, and its aims were to allow KTs to (i) Understand the relevance and need of science education in the early years; (ii) (Re)construct subject content and pedagogical knowledge; (iii) Know international guidelines for science education – namely STS education; and (iv) Promote the development of adequate teaching strategies in kindergartens.

The practical activity detailed in this paper was validated by a KT who attended this 50 hour workload in-service training program, intended to promote the implementation of the 10 activities developed in this project. The 25 contact hours included theoretical (9 hours) and practical (12 hours) sessions, and a final four-hour group session intended to promote group interaction, leading to the discussion, analysis and reflection of the whole process and its outcomes.

Implementation session

"*Granny's toys and mine*" was implemented in a kindergarten located in the city centre of Mirandela, in the Bragança district (Northern Portugal). Although the KT chose to conduct the initial part of the activity with the whole group (25 children), the practical activity was later developed with a smaller group of 5 3-4 year-old children, taking approximately a total of two hours.

The KT preceded the suggested context strategy in the teacher's guide by another derived from her class previous experiences. A child's grandmother (granny Dulce) was asked to visit the class and talk about her childhood, bringing also some of her old toys and sharing memories of her childhood play. Those toys were later kept in the classroom, and children could explore them, with proper care. It was in granny Dulce's company that the class watched the video included in the activity resource pack (the **context-activity**), later discussing what they saw and comparing it to their present lifestyle. Once again, the grandmother was an important element to facilitate children's relation with a past time and lifestyle, as she impersonated it.

Throughout this talk, the KT promoted the discussion of children's ideas. She focused on the materials used to make the objects shown on the video and on the different kinds of toys represented, always trying to direct children toward the evidence of their answers.

In the practical activity (**Figure 6**) children were challenged to form two different groups of toys: those which could have belonged to their grandparents and those which could have not.

After allowing for a period of children's spontaneous manipulation of the toys, the KT engaged them in more focused observations, questioning them if a given toy could have belonged to granny Dulce. Children would observe it and think about what they saw on the video, about what granny Dulce told them about her childhood and about the facts referred to on the previous discussion of their ideas.

Throughout the activity children were asked to justify their choices, thus providing opportunities for the development of a variety of science process skills and attitudes.

Their answers, and the reasons presented to justify them, were discussed among the children, through heedful guidance on the KT's part that would contribute to conceptual scaffolding. She intended her questions to lead children to focus their attention on the toys' details which could help situate them in one of the epochs. This intended to allow them to gain and construct some meaning about the core concepts involved and to build knowledge from children-generated ideas.

After all the toys were placed on their respective sets, the KT promoted the discussion of children's ideas regarding what they did, leading to the **systematization** of the activity learning outcomes.

The KT then presented children with the puzzle pieces referring to the **assessment activity** (**Figure 7**), asking them to try and match the correct pairs. As they did this, they were asked to compare them, to try and explain the differences found between them and to explain why they thought those two pieces were related to each other. While promoting talk, as an active assessment activity (Weavers, 2008), this lead children to reveal their understanding about the concepts involved and their learning progress.

Figure 6 – Children manipulating a wooden bird and a magnetic drawing board.

Figure 7 – Children matching puzzle pieces showing two telephones.

Data analysis and results

The implementation sessions were audio-recorded and photographed, which, along with handwritten data, allowed for a posterior accurate transcription of the occurred events. Analysis of the didactic strategy was based on the evidence children gave, through their behaviour, performance and words, of mobilising the specific set of capacities, attitudes and values. Knowledge was ascertained considering their responses throughout the activity, and moreover during the assessment strategy, focusing on the matches they made and the justifications given for making them.

Throughout the activity, and relating to the existent resources, children gave evidence of mobilizing a set of skills, attitudes and values, while constructing new and more complex knowledge, as they later revealed on the assessment activity. Analysis of the whole process was focused on evidence children gave as to the mobilization of **science process skills**, **scientific attitudes** and **content knowledge**.

Regarding **science process skills**, when they were asked to *establish comparisons* among the different toys, children were required to *make focused observations*, trying to *identify differences and similarities* among them. They often did so not only by comparing the set of toys with their own, quickly determining which could be considered as the more recent one, but also recalling what granny Dulce showed them and talked about. Children also established relations with scenes depicted in the movie they watched, having recalled such examples to justify their choices upon placing a given toy in its respective set. They would often say "*Because I had such a tricycle when I was smaller*", "*Because my grandfather has a pen like that at home*", "*Because its like the one granny Dulce showed us*" or "*Because the car is like the one Charlot drove on the movie we saw, and its nothing like my father's car*".

Children mobilised their *communication* skills all through the activity, mainly by *describing what they saw and did*, but also by *sharing and discussing their ideas* on the subject. They have shown to be able to *construct argumentation*, albeit at an elementary level, when they recalled the aspects in the given toys which led them to choose the set they thought it belonged to. This was supported by the KT, who promoted children's talk, also as a means to develop their *reasoning skills*. This guidance and conceptualization main purpose was to allow children to evolve from mere description, and to engage them in higher stages of reasoning, while challenging unsuitable concepts and contributing towards the construction of more precise ones. Children also *used specific vocabulary* (key-words) to justify their choices (ex: "*That's too technological to be my grandparent's motorcycle*"; "*Scientists hadn't invented automatic escalators like those before*"), leading us to conclude that they were connecting it to their everyday lives and gradually building a range of functional vocabulary to stand for future situations. This is important to consider in a Vygotskyan perspective, which values the teacher's and children's communicative attitude throughout the activity as a means to enforce the child's conceptual understanding. While sharing and discussing their ideas and understandings children are engaged in a purposeful communication process, leading to the promotion of authentic language usage.

Children's actions and explanations throughout the practical and the assessment activities give evidence of being able to *interpret information* (focusing on either the toys details or on their 'reading' of the images of the puzzle pieces), *evaluate it* and *construct on it* to build more solid knowledge about the concepts involved.

The children's attention to the toys' details and the time they seemed to take in considering other's ideas, also suggests that while *making decisions*, they were also showing some sort of *critical thinking*. They often considered both the facts and their colleagues' ideas to make up their own mind as to where to place a given toy. Their effort to tackle their natural impulse to distribute the toys on their own was, nonetheless, visible.

Children also demonstrated to be able to *work autonomously*, both during the practical activity as well as the assessment one.

They have given evidence of *inferring*, mostly on the assessment strategy, having justified some of the relations among the objects illustrated in the puzzle pieces using knowledge accessed during the practical activity. When asked why he paired a wooden wheel (wagon) with a rubber one (car tyre), the child argued: "*We've already said that in the old days they could only use wood to build things*". Notwithstanding, throughout the whole practical activity children were observed to support their choices with knowledge drawn form granny Dulce's visit, the movie and information discussed throughout the activity.

Analysis of the implementation session of this activity was also focused on evidence regarding the mobilization and development of **scientific attitudes** on the children's part. These should be considered important not only in the context of school science at kindergarten level but also as a way to interpret and to interact with the world around them, as a science literate citizen.

KT's main focus should be to build on children's curiosity in order for them to construct new and more precise knowledge about the word. Throughout the activity, they revealed *curiosity* about aspects of the different objects at their disposal, and also about the situations depicted in the introductory movie. Their questions ("*Why does that train make so much smoke?*"), their remarks ("*That plane does not look like 'our' planes!*") and the attention they paid from beginning to end, allows us also to conclude about their *interest in understanding the world*, namely on the concepts involved in the practical activity.

Although rather young, some children showed to *consider others ideas and opinions*. This happened mostly due to the KT's care in promoting a debated discussion of both facts and ideas, insisting on asking children if they thought a certain idea was correct, and if so, why. They appeared to be able to analyze a given idea, and to give arguments for or against it, revealing *willingness to consider evidence and to change ideas*. This can be inferred when children were confronted with facts that didn't sustain their decisions ("*Yes, that truck operates on batteries, so it couldn't have belonged to my grandparents!*").

In both activities, (practical and assessment) children gave evidence of *perseverance*, as they showed continued effort and determination to accomplish the purpose of the activity, handling their doubts and insecurities. When faced with a toy which they did not know where to place, their reaction was to ask for someone's opinion (the KT or a colleague), in order to help them decide, not giving signs of resignation or frustration. This also leads us to conclude that these children were able to *work cooperatively*, as in no occasion we witnessed any altercations among them. They waited while others chose an object, considered where to place it and explained their choice. They listened to one another and respected the others' opinions when they differed from theirs, contesting them when they disagreed ("*Can't you see your grandmothers drawing board couldn't have been a magnetic one?*").

Other evidence to be considered in the analysis of the implementation session regarded the children's construction of **knowledge**, assessing the ideas they showed throughout the activity, and the choices they made.

Children demonstrated to have constructed some general idea about the *diversity of materials available to man, both of natural and non-natural origin*. Although they did not express themselves using these precise terms, we can assume they were able to construct some knowledge about these concepts, inferring from the choices they made throughout the activity and, mostly, the arguments they gave to justify them. Children would often give justifications like "*This is made of wood, so it could be granny's toy", or "This is plastic, so it could not*", leading us to believe that they established a simple criterion to separate them: the material they were made of. Children clearly focused their attention in this characteristic of the toys to choose the set they found to be the correct one: those that could have belonged to our grandparents (toys made of materials from natural origin and metals) and that could not (toys made of materials of non-natural origin).

Evidence regarding the children's understanding concerning the *presence of growingly complex equipment* in those toys was also observed, albeit they did not resort to this criterion to support their choices as often and as clearly as they did with the one presented in the previous paragraph. Nonetheless, they focused on mechanisms such as solar cells, magnets and batteries to exclude a given toy from the set of "granny's toys" ("*Do you really think your grandmother could have had a toy with buttons which make all those lights and sounds?*").

Again the KT had an important role in allowing children to be familiarised with some science vocabulary in order to describe and explain the concepts involved. Mainly because of the

KT's input did they use words like "science", "technology", "modern" and "scientist" when characterising some of the toys they considered to be recent ones. Although the underlying meaning that those words may have for the children remains to be fully determined, we can however assume that some meaning was constructed.

Therefore, considering the content that *science and technology together allow for a growing diversity of materials and more sophisticated technology in toys*, we can only infer that children were able to form some kind of understanding about the processes and nature of science. Realising that science and technology are embedded in our daily lives, in this case, in most of today's toys, children concurrently build on the understanding that science and technology serve a useful purpose in our livelihood. Furthermore, to have formed some elementary idea about the dynamics of science and technology evolution towards more complicated objects will have contributed for the development of children's positive attitudes toward science and technology.

CONCLUSION

As a starting point, we assume that, on one hand, good quality teachers, with up-to-date knowledge and skills are the foundation of any formal science education system and, on the other hand that innovative curricula and ways of organizing the teaching of science are required to improve the science and technology literacy levels of the next generations. The wider project in which the development of this activity is included aims at contributing towards the required changes in current science teaching at the kindergarten level, in the Portuguese context. Science curriculum is therefore considered as a continuum (Braund; 2008).

We were able to gather evidence that, on one hand, the developed teacher training program contributed for KTs to construct knowledge to support the developed activities, and, on the other hand, that these activities can be considered as a means to achieve innovative practices in science teaching.

The assessment of the practical activities was based on the analysis made by both researchers and KTs who implemented them in a design-based research perspective, generating knowledge that can be transferred to real-context and can inform practitioners and other designers.

As the one presented in detail in this paper, all activities were considered adequate teaching strategies and didactic resources for the development of the kindergarten science curriculum. The concepts where considered appropriate and relevant, leading children to mobilize a set of skills and attitudes that are, in a Vygotskian perspective, well within their zone of proximal development.

The aforementioned process provides empirical evidence that the implementation of a set of specifically developed science learning strategies, such as the one presented, shows that it is possible to promote a wide range of scientific competences (knowledge, skills, values and attitudes) that should occur in any kindergarten context. This concurs with recent research showing young children's ability to do science as being underestimated, and presenting kindergarten as an eligible context for science teaching.

Moreover, it shows that when engaged in teaching strategies which are embedded in contexts familiar to them, kindergarten children are able to construct ideas not only about the presence of science and technology in our daily objects, but also about the evolution of science and technology.

External relevant people, like granny Dulce, may prove to be an engaging approach to bring children to relate with society, as a mediator of their kindergarten experiences with the inherencies of the modern world.

This strategy showed positive results in providing children with some nexus to the adults' complex world, relative to the underlying articulate relations to be found between the socio-cultural and human aspects of life and science and technology.

Evidence gathered throughout the implementation sessions leads us to consider new teaching strategies that would allow children to deepen their understanding about the evolution of science and technology. They have shown to be able to place a given object in two distinct places of a time line (their grandparent's time and the present day). This suggests as a pertinent extension activity one where children would be asked to place several images of a given object (cell phone, television, vacuum-cleaner…) in distinct places of a time-line. The images would illustrate the object as it was built in different periods of time, representing the visual features that portray its evolution. Likewise, it would be important to elaborate on children's knowledge about this subject, developing a teaching strategy that would allow them to understand that there are objects today which simply did not exist, for example, in their grandparents' days.

Teacher training programs have limited impact when it comes to reaching the whole teacher community. It is therefore assumed as important, in the context of the present study, to assess the teaching strategies impact with KTs who will not attend such a program. We are basing on the assumption that these activities should be able to sustain the development of children's scientific competences, regardless of KTs access to specific in-service training programs.

Children should be engaged and empowered, as to develop into lifelong learners in science, hence the need to provide children with multiple opportunities for joyful explorations and discoveries in science.

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PARTICIPATORY RESEARCH IN EDUCATION FOR SUSTAINABLE DEVELOPMENT

Lena Persson

Stockholm University Sweden

lena.persson@mnd.su.se

Iann Lundegård

Stockholm University Sweden

iann.lundegard@mnd.su.se

ABSTRACT

Researchers on education for environmental education, EE, and education for sustainable development, ESD, have discussed the affect of student's life – experience on the students ability to develop action competence. In this study we want to investigate in what way an action research oriented environmental education contributes do develop a pluralistic view of sustainable development. The research object was the students' ongoing reflections and interviews. The data was collected logbooks, transcripted focus group interviews and transcripts from a teacher interview. In the beginning of the project many of the students reflections emanates resignation and dejection. But after a few weeks the action research process and the sensibility to the students reflections guided them into empowerment and also helped them to start thinking of strategies and actions for the future.

Keywords*:* *Action research, lifestyles, reflections, Education for sustainable development, pluralism*

INTRODUCTİON

In 1992 my school was invited to attend a project called ENSI, Environment and School Initiatives. There were six schools from Sweden who participated in ENSI. The project was initiated in 1986 in OECD's Centre for Educational Research and Innovation (CERI). Our school attended the second period of ENSI, which ended 1994 at a conference in Braunschweig in Germany. There were 20 countries participating the second period of ENSI. Harriet Axelsson, the Swedish coordinator documented the action of the Swedish schools in her thesis (1997). Our schools' teachers taught about environmental questions before ENSI started, but our education had just been a transformation about facts around the situation in our country. We realized that if the students were to learn awareness of the environment we had to change our approach to education. Our involvement in the action research methodology started with a learning process about photosynthesis. The project started with one open question:" What is life?" Then the students' went on by designing experiments with plants to find out and understand what they need to live. A short summary is that the students learnt a lot about working practically with plants, and when they two years later were tested by the national evaluation their knowledge of Photosynthesis were solid. This is one of the reasons why I once again choose to investigate, in cooperation with a science teacher, how Action Research can contribute to develop a democratic education in science and sustainable development? *The second author is my supervisor* because this article is part of my thesis at Stockholm university.

BACKGROUND

Researchers on education for environmental education, EE, and education for sustainable development, ESD, (Chawla, 1994; Shuman, 1999; Almers, 2009) have discussed the affect of life – experience on people's ability to develop action competence. Chawla and Shuman pointed on early experience in childhood. Almers (2009) research- question was: "How do young people experience that they have developed aspects of action competence for sustainable development?" Her definition of action competence is; A willingness and capability to act for changes in individual life-style, as well as for structural changes of society, in a way that includes responsibility for present and future generations." (p. 278)

Almers points to 4 different motives for young people to be committed for the environment.

1. Emotional reactions initiating a wish to change and willingness to act
2. Longing for meaningfulness
3. A desire to feel comfortable with what you can contribute
4. Longing for spirit of community (fellow-ship).

These young people have been inspired to interest on environmental issues by parents, informal education in idealistic organizations and by other grown up people. Only one of the interviewees mentioned that a teacher had impacted on him. If we look at Almers' result, we see differences from Chawla's and Shuman's research on how experience of nature and environment in childhood had an impact. Kaplan's (2000) tell us that the most important factors in environmental engagement were: To feel competence to act in questions about sustainable development, to be motivated to act, and to feel that it makes a difference to be able to make changes in life. Kaplan suggests a way of teaching, where you shape structures for people to understand reasons of environmental problems, possibilities to make research around them, and to participate in groups, discussing how to solve those problems. Also Almer's research confirmed Kaplan's results and the importance of students' sense of ownership.

In my research I want to address the question, if there are possibilities to arrange an educational situation at school where students acquire action competence. My research relates to Öhman's pluralistic view of ESD, (2008).

In the Swedish curriculum (Lpo 94) we can read:

"Democracy forms the base for national school system and it is not enough to have knowledge about fundamental democratic values. They must be brought out by using democratic ways of working and preparing the students for active participation in a civil society".

Öhman (2008) claims that, if our purpose with education is to attain the proposals in the Swedish steering documents, then the only way to address the education is the pluralistic. What is the way he is advocating? The pluralistic tradition strives to emphasize different perspectives, views and values, which are treating different questions and problems about our world's future. To reach that aim we need to bring the environmental questions into the classroom, so that the students will have the opportunity to discuss them in reality. Then they can decide for themselves in which direction they want to take different messages further. Such discussions are an important part of the pluralistic education. This is the only way to give the students enough competence to make their own decisions on environment issues after their formal education.

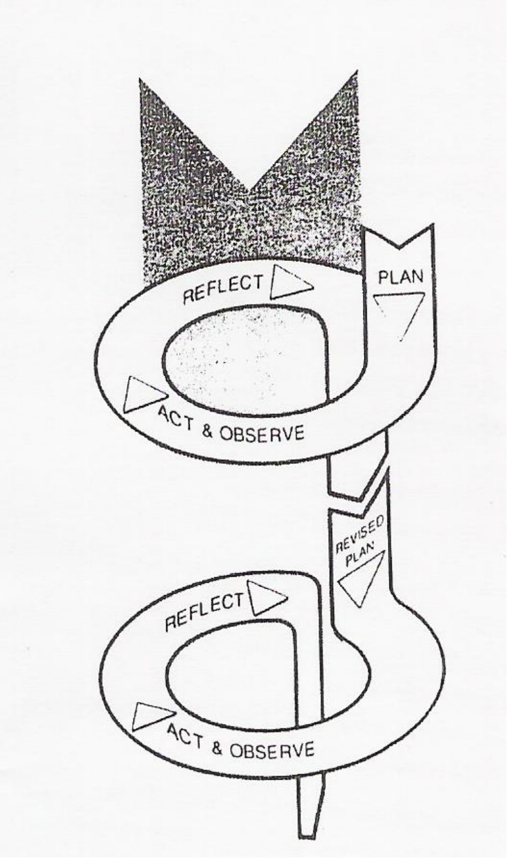
Action Research (AR)

Action research, AR, is being used in corporation and enterprising when the aim is to reach a change. Action research is described by Posch and Elliot (1994) in three levels.

Students are action researchers when they reflect over their learning.

T*eachers* are action researchers when they observe, reflect and change the education, develop professionalism.

The r*esearcher* is action- researching, when she/he is reflecting on what is happening in relation to the research question. In the school situation the teacher, researcher and the students plan action together, carry it out, observe what happens on the different levels and reflect on their result. The reflections perhaps identify new problems and then you have to start again from square one. The learning circle tries to explain the process.



Kolb&Fry (1975).

The Ensie- project (Posch 1991) was focused on the students' development of what they called dynamic qualities, competencies, such as initiative, independence, commitment to act and readiness to accept responsibility. The ENSI- project was based on the hypothesis that *environmental awareness and the promotion of these dynamic qualities are reciprocally related to each other,* Posch (1991 p.13).

AIM

The aim of this research is to investigate in what way Posch's elaboration on action oriented environmental education can be combined with a pluralistic view of Education for sustainable development, ESD.

Research questions
The main research question in this project is*:*
How can Action Research contribute to develop a democratic and action oriented education in sustainable development?

More concretely this study has focused on the question:
In what way can the students' reflections be used to develop an education sequence in sustainable development?

METHOD

Participants: the researcher, a science teacher and the students in year 9 at a secondary school situated in a suburb outside Stockholm city. The research object was the students' reflections in logbooks and interviews. These are paid attention all the way through the study. The researcher and the teacher will learn about learning during the whole project, they act as both subject and object in the study. The research data was: 1. collected reflections from the students' logbooks. 2. Transcripted focus group interviews from a student group on three different occasions. 3. Transcripts from a teacher interview at the end of the project.

After the students' reflections in logbooks and interviews, I transcript everything and after that the teacher and I discussed, how we should take care of the reflections in planning the next step in ESD.

We checked if the student group needed help finding more data about the subject they were studying or if they had some other problems in their groups. Then we helped them to solve their problems. At this stage we collected all written material and interviews. We did not only select some of them, because we wanted everyone of the students to go forward with their studies. In this article I only show some of the things the students made reflections on and later on in my thesis I will show more reflections, and how the teacher and I took care of them in our plans.

A.R. in the school practice?

The teacher got all the information, both oral and written about AR from me. I also informed her that my central research interest is around the students' reflections and not the teacher's action in the classroom. She was informed about the performing, that we were doing everything together on an equal level. We started together by planning the introduction for the students.

At the beginning we wanted to give the students a holistic view of the issues. Therefore we started the first lesson with an introduction on the environmental situation, both on a local and a global view.

The second lesson the teacher and the students had a discussion about in what ways peoples lifestyles have an impact on the environment; for example food, clothes and transports. After that the students got a question: *"What in your life-style and the impact of* *this on the environment do you want to investigate more?*" From this question they then created interest groups.

The first session was followed by a day at a museum and an exhibition called Global Change. The first question in their log- books was then: "*What was your experience of the exhibition and what were your immediate thoughts?"* The second question was: "*What do you think is the biggest challenge for human beings in the future?"*

Here are some reflections from the students:

" *There were so much information which was really interesting, but I was shocked. It was so terrible, what they showed in the film. More people ought to think about the future and just not ignore serious problems, just because they are not affected by them. (Girl 1.)*

"It was interesting to learn about all the things which impact our climate. It makes you realize how bad the situation really is. I thought it was terrible how we have destroyed the earth and made it an unsafe place to live in. More and more catastrophes are going to occur and more animals are dying out." (Girl 2)

" *It was not good that USA had not signed the Kyoto agreement. The life-style is going to change and you should be prepared for that even if you don't like changes. You have to do it anyway." (Boy 3)*

"*It was interesting and instructive, but it was also very frightening, because you really saw the difference now compared to 2000 years ago. I began to think about how the life will be for my grandchildren and great grandchildren - if they have to be floating on plastic boats because the ices are melting or if they dare not to go out because the ozone layer is disturbed and they are afraid of getting skin cancer*." (Girl 9)

" *We must do something with the environment. We must start driving environment friendly cars and stop the import of unnecessary articles from China, even if they are cheap because the transports are so long with carbon dioxide letting out." (Boy 4)*

As showed above many of the students reflections emanate resignation and dejection. This brought us to the decision to bring the problems up to another level, where the students did not have to feel so much individual responsibility. The teacher led a discussion about society's responsibility in economics and politics and about Individual organizations, which people can attend, to make impact on politicians.

After this the students in a more empowering way started to think in ways of actions, which make difference on the environment. Most of the students also connected the green - house effect to carbon dioxide and transports.

One question in the focus group interview was "Which is the most challenging question for the future?" Here is a short part of the discussion:

Ale: "*Economy is a barrier because it's difficult to start environment projects. They are so expensive in the beginning but later on they can be profitable."*
Fanny: "*Emissions, Take the step to travel by train or bus instead of cars. US can take the step, and then other countries might follow"*
Ale: "*It puts pressure on other countries"*
Fanny: "*People in western countries are worse and we have the most money but if we are doing the right thing and helping the developing nations –It will make a big difference"*
Peter*: "It would be worth going by bus or train, if they lower the prices. More people will use the local transport instead of cars."*

In this part of the project many of the students had begun to reach for solutions instead of only focus on barriers and hinders. Most of the students tried to find the solutions on transport questions and mentioned economy as a great barrier. They seemed to understand the green-house effect in relation to carbon dioxide emissions.

The final group works

After this short presentation of some of the episodes in the process I will just give a short presentation of what kind of recommendations the students have to help people create a better environment.

Two boys and one girl showed alternatives to cars, better public transport and those who had to go by car can choose ethanol - or electric motor cars. If you are walking or going by bike shorter distances, you also save the environment and you feel better, get healthier. The students finished by discussing the future, that the whole world must support the decrease of carbon dioxide. They presented an idea about producing bio-fuel from vegetable oils and vegetables from restaurants. They ended their power-point presentation with a beautiful bike with the text: "Help save the world - Go by bike!"

Two girls discussed *ecologic food.* They served ecologic lemonade for all the students to show them that it tasted as well as other types of lemonades. They had visited an ecological shop and also an ecological farm. They discussed prices on ecological foods and said that if more people were eating that food, the prices would go down. They finished off by showing *nice menus* with ecological food and the last picture showed a happy pig outside instead of being inside all their life. They ended with saying: "This pig is happy".

Two girls and a boy had studied the clothes impact on the environment. They talked about eco-clothes, poison and overconsumption. They had calculated how far the clothes had been transported around the world, before they get to the consumer and how much carbon dioxide outlet the trip had caused. They also talked about the textile industries in India causing 25 000 peoples' deaths each year because of all the poison in the clothes. Most of the clothes come to Sweden from China. In what way could we help to change the situation in the factories for those people? It's a moral, political and economic question. Would you like to buy more expensive clothes or is it okay that they are produced by children in dangerous factories, if they are cheap. We should shop for clothes with quality instead of quantity was their last message.

Three boys made a film, which all the students and the teacher and I found very funny, even if they had a serious message that people would afford to buy ecological food if they don't throw away so much food like they are doing today. They also answered questions from people phoning them and asking what kind of food products they recommended.

The last question in the focus group interview was "How can we together change the world to become a better place for future generations?"
Here is a short part of this discussion:

Ale: *By everything - everybody can do small things. You can impact both in practical and political ways.*
Fanny. *By trend-setters*
Ale: *Not only trends, you have to act in ethic ways.*
Interviewer: What about Al Gore? Has he got a lot people engaged? Even if he flew around Sweden and J (a girl in their class) thought it was wrong.
The group (in unison*): Yes. He was good*.
Albert: *You should not only talk!*
Fanny: *My parents say that, I am a NATO person -No Action Talking Only.*
Peter: *The politicians must be unified all over the world. Then the economics is no problem if everybody supports the same thing.*
Mark: We must act now and produce environmentally minded things like vehicles, industries and better fuels .The whole world must work together. It's too late in 30 years time, the glaciers will have melted.

Interviewer: Is the nature as important as the human beings?
Ale: *If there is no nature, you will miss it – The breeze in the trees, the wind and water*.
Peter: *All the other countries must get help – We need healthy nature both here and on the other side of the world.*
Albert: *When is the new Kyoto agreement coming?*
Interviewer: In Copenhagen there will be a large environment meeting in December this year- We will see what happens there.
Mark: *China and U.S. are most important!*
Ann: *Rich countries must help more. Everybody on earth must respect plants, animals and humans. The whole world must work together.*
Mark: *Nobody should ignore these important environmental questions. The whole world must help each other.*
Fanny: *All countries should take care of their own waste products and not transport it to other countries. They are not going forwards in that way. The rich countries should take responsibility and they have the most impact. Therefore they have the most influence.*

Another question all the students got in the end was: Can you now after this education follow the media debates around ESD and even make your own decisions in your first political election?

Ann said:" I wouldn't have been able to before this project, but now I am able to do it" The others in the group said:" Yes we are able to do it now. Another student said: *"Everybody should have the opportunity to learn about these things."*

SUMMARY

The concrete question was: *"In what way can the students' reflections be used to develop an education sequence in sustainable education?"* In the first reflection occasion the teacher and I had to meet the girls, who were worried about the future. The second time, we only checked up, if the groups needed help in some ways and we helped those who asked for help. On the third occasion we just wanted to check what they had learnt about the environmental situation in the world. We, the teacher and I, can say that it worked fine to follow the reflections and help all of them who needed help, because if they are working individually, they often don't want to ask for help in the classroom. I have experienced that the teacher get more reflections over the students' learning if they were given time to write down them. I also learnt a lot by listening both to the teacher and to the students and to be quiet and wait for the teacher's and the students' thoughts.

The research question was:" *How can Action Research contribute to develop a democratic and action oriented education in sustainable development?* "
In this research project the students were taking initiatives, planning and acting, as they developed their dynamic qualities (Posch ,page2). After that they were discussing in the logbooks and interviews about the challenges on the environment both local and global.
What about the question Almers asked (page 2) "*What possibilities have the schools got to arrange education in sustainable development to encourage students to act in environmental questions?"*

In this project I have showed that it is possible to do that, but I am not saying that you have to do it the way the teacher and I have done. What I can say is that a democratic way like the pluralistic way, where the process is student driven (page 2) is to recommend if you want to develop students' self-esteem.

How could the teacher and I see that the students had learnt about ESD?
In interviews and logbooks we saw how they talked about different environment issues, for example greenhouse-effect and how to limit it, and they thought about transports (p.4 and 5) and that showed that they understood some of the underlying reasons to that environmental problem. They also talked about the same thing in their reports (see p.5) and about saving

electricity at home. This was were we saw, that they were understanding the relation between fossil energy and carbon dioxide. In their final group reports we also found in the recommendations to class-mates, that they have got a deeper understanding of some environmental issues. We noted that they understood the global effect of carbon dioxide outlet when they talked about the Western Countries to help other countries towards a better environment (p.5,6). There are a lot of more things to analyze in my research about teaching and learning and about the action research and teacher sensitivity and I am thankful for the ideas I got from the reviewers, and I will have much use of them further on when I am writing my thesis. This article was mostly about the Education for Sustainable Development, but I will look later on at other parts of my research, so I agree that there are limitations in my study.

Referring to the *teacher's last comments*:

About students' progress:
"The work has been meaningful for all the students, as for the first time at school, have got a deep-sea diving in their own interest areas on environment questions. They have got a genuine insight and deepening in many environmental questions by their own work and the other groups' works. I was most impressed by the students' engagement on the topics they had chosen. They have been disciplined and worked all the time. Some students were ready before the others and they helped the other students' with power- point presentations."

About action research:
*"*When I think about this project I only have good thoughts about it. I have worked alongside the researcher and shared thoughts and ideas. I have felt confident, when the researcher has been in the background and supported me in questions, which I have not been so sure about. The students have felt that both of us were there for their sake, helping them when they needed it. I have learnt a lot too about ESD and also about that way of working".

In what way did the students reflect on their life-styles?
Some girls had started looking at where their clothes were from. Both the boys and girls discussed ecological food and about how to save electricity. The students seemed to be engaged in environment questions, and my hope is that they will go on learning more about environmental issues in future. They will do it, if Dewey (1916/2007) was right, when he said "if they get inspired now, they want to learn more in the future."

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ICT IN SCIENCE AND TECHNOLOGY TEACHER EDUCATION

Mateja Ploj Virtič

Faculty of Natural Sciences and Mathematics

University of Maribor

mateja.ploj-virtic@uni-mb.si

Mateja Pšunder

Faculty of Arts

University of Maribor

mateja.psunder@uni-mb.si

ABSTRACT

Due to their specific nature, science and technology are two fields that require a high level of technological equipment. The Faculty of Natural Sciences and Mathematics, which educates teachers of natural sciences and technical subjects, must therefore closely follow technological developments dictating a fast pace. It must further provide student teachers appropriate digital competencies that are inevitable when working with the young population. This article presents a research conducted among fourth-year student teachers of natural sciences and technology. The research was conducted in order to see how students evaluate the conditions of using the computer at the faculty, their opinions on the necessity of using the computer in class and digital competencies obtained during their studies. The results show that students are not satisfied with the computer equipment that is available at the faculty, while they at the same time have high expectations about digital competencies, as they believe that using the computer in class is very important.

Keywords: *science and technology, teacher education, digital competences.*

INTRODUCTION

The teaching methods and styles in the educational process changed through history and have always aimed at higher quality. In the last 15 years, computer use increased reflecting itself of course also in the field of education. In the field of education, the computer provides a broad range of applicability. In addition to its educational function, it also enables communication on various levels and thus the use of the term information and communication technology (ICT).

In June 2007, the Ministry of Higher Education, Science and Technology adopted the Strategy for the Development of the Information Society in Slovenia through 2010 (Si2010, 2007). The strategy aims to facilitate effective use of ICT to boost the country's competitiveness and productivity and provide a balanced social and regional development and improve the quality of life of the society as a whole and of each individual. The strategy also covers the sphere of education and research which are the main activity of universities. By including ICT, universities primarily raise the quality of their offer in the education market. The increased trend of implementing new technologies in educational institutions however increases also the inefficient and unprofessional use of these technologies. Great care needs to be taken in the implementation of modern technologies, as their excessive application can have the opposite effect. In preparation and implementation of e-material, guidelines such as professionalism, the educational and didactic design and technological implementation need to be considered (Dinevski & Lokar, 2006).

At the University of Maribor, the implementation of e-learning is in a very active phase but the actual utilisation of e-learning depends on each individual faculty. Faculties providing programmes for student teachers must pay special attention to the implementation of ICT in their study process. Education of teachers is namely the starting point in the knowledge transfer vertical (see Diagram 1).

Faculties providing programmes for student teachers are those that transfer knowledge and competencies to teachers.

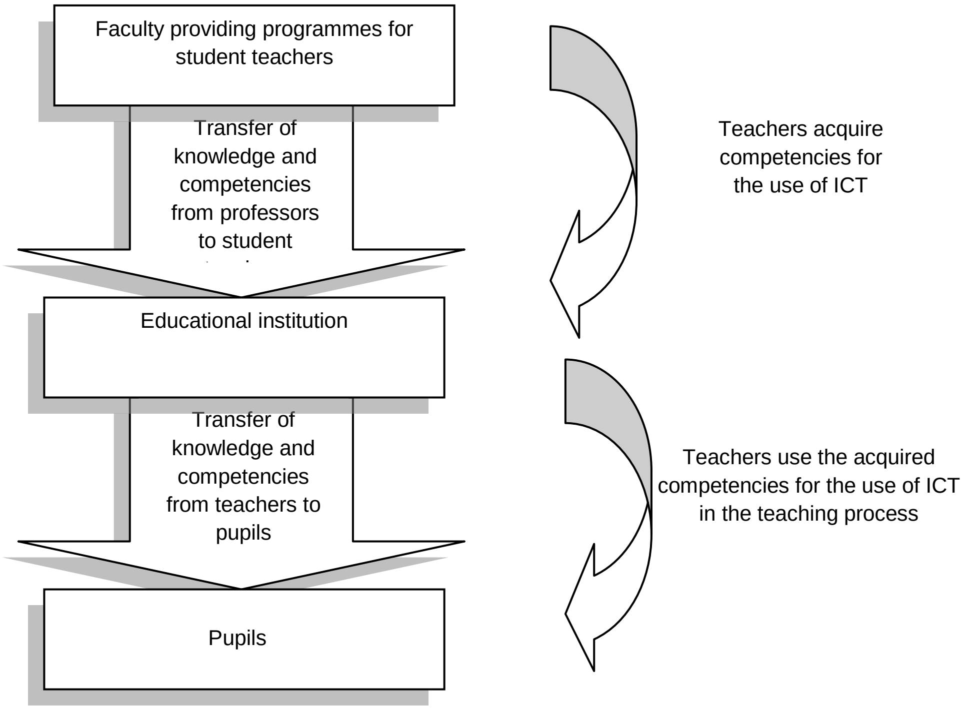

Diagram 1: Knowledge transfer vertical

Mastery of new technologies, especially information and communication technologies is a competency that has been added to the list of competencies in the last decade. Teachers, who have concluded their studies ten or more years ago, therefore did not acquire the required competencies during their study. For these teachers, corresponding training has been organised that has however not been provided separately according to individual subject areas. Another factor that is strongly related to the use of ICT in education is the field of teaching. Due to the specific differences of individual subject areas, the use of ICT strongly differs among teachers of different subjects. Our research has further shown that teachers of natural sciences, mathematics and technology and design are more receptive to novelties. Today's students are the so-called computer generation that grew up with computers and the rapid development of ICT. We therefore assume that the use of ICT in education should not represent a major problem. Nevertheless, prior to implementing ICT in the educational process, their eventual desires or even advice need to be heard. The paper presents the research conducted among student teachers of the fourth year of the Faculty of Natural Sciences and Mathematics. The results of the study present their opinions on the conditions of using the computer at the faculty and opinions on the necessity of using the computer in class and on the digital competencies obtained during their studies.

THE COMPETENCIES IN TEACHER EDUCATION

Lots of authors (Hermans, Tondeur, Vanbraak, & Valcke, 2008; Loveless, 2003; Ploj Virtič & Pšunder, 2009) have studied the use of ICT in education. They have predominantly shown that the decisive factor for a successful implementation of ICT into education is the teacher. This is a logical consequence of the fact that it is the teacher who directly performs the teaching process and at the same time the one who uses ICT.

Bitner and Bitner (Bitner & Bitner, 2002) researched efficiency of teachers in using ICT and have found that it is the skill and attitude of the teacher that determines the effectiveness of technology integration into the curriculum.

Ertmer (Ertmer, 2005) stressed the teacher or his beliefs about the transformative nature of new technologies as being the most important factor for the use of ICT.

The issue of students' ICT uptake in the classroom is of crucial importance, for it has been argued that use of ICT in teaching during school practice will lead to competent and confident in-service use, while lack of it will mean that future teachers will make little use of ICT.

Galanouli and McNair (Galanouli & McNair, 2001) researched student teachers' use of ICT on teaching practice and concluded that it is necessary for effective future use of ICT in the classroom. They report that there are a number of factors affecting the use of ICT by student-teachers in their school placements. One of those is appropriate digital competencies.

METHODOLOGY OF RESEARCH

The study reported in this article was conducted as a part of a post doctoral project "**Analysis of the Higher Education Technical Didactics and Creating the Application Framework for Transferring Technical Knowledge**", which seeks to evaluate the ICT implementation in teacher education. The research was conducted among students of natural science, technical and computer science, students of social studies and humanities; and students of the department of elementary education. This article focuses on students of natural science, technical and computer science. The article presents the student teacher part of the research, which explores the conditions of using the computer at the faculty, the students' opinion on the necessity of using the computer in class and the obtained digital competencies. The participants in this study were 87 students of natural sciences, mathematics and technology from the Faculty of Natural Sciences and Mathematics of University of Maribor in Slovenia. Data were gathered via an anonymous questionnaire. Research questions in the questionnaire were divided into three parts. We were interested in the opinion of student teachers of science and technology:
- on the conditions of using the computer at the faculty;
- in their expectations regarding the use of ICT; and
- in the digital competencies obtained during their studies.

RESEARCH RESULTS

Students' opinions on the conditions of using the computer at the faculty

In the first part of the research, we were interested how student teachers evaluate the conditions of using the computer at the faculty. We were interested if they see the conditions as supporting or hindering the use of the computer. We were interested in obtaining their opinion on the following conditions: availability of computers at the faculty, performance of computers at the faculty, software of computers at the faculty, internet access at the faculty and internet access in the town of study.

These conditions are probably the important factors influencing the use of the computer among students. The students used a five-stage scale to express their opinion on whether the conditions for the use of the computer are favourable or not. Statements relating to individual conditions were appointed numeric values from 1 – "I completely disagree" to 5 – "I completely agree". The more the students agreed with individual statements, the more they believe the conditions to be favourable for the use of the computer. The results are presented in Table 1.

Table 1: Mean of Rating Scores[a], Standard Deviations and Rank Orders[b] of students reporting on the circumstances regarding the use of the computer

Circumstances regarding the use of the computer	Mean	SD	Rang order
Internet-access in the town of study is well arranged.	3.6782	1.07286	1
Internet-access at the faculty is well arranged.	2.4253	1.17762	2
Software of computers at the faculty meets the study requirements.	2.1264	1.11860	3
At the faculty, there are enough computers available for study purposes.	1.8391	1.03287	4
At the faculty, the performance of computers is sufficient for study purposes.	1.6207	.81042	5

[a]A higher score indicates that students see an individual circumstance as more favourable for the use of the computer (1 = is not favourable for the use, 5 = is very favourable for the use)
[b]A lower rank indicates that students see an individual circumstance as more favourable for the use of the computer (1 = most favourable, 5 = least favourable).

On average, the students expressed a negative standpoint on four (out of five) statements. The only statement receiving a positive evaluation related to internet access at the town of study. This means that students see the conditions of using the computer at the faculty more as unfavourable rather than favourable.

They were least inclined towards the statements that computer performance at the faculty is sufficient and that there is a sufficient number of computers for study purposes. Software available on the faculty's computers and internet access at the faculty received slightly more favourable but still negative evaluations. Such results are undoubtedly not encouraging, as good computers and software can serve as one of the important starting points to motivate students to use computers for study purposes.

In the remainder of the article, we will briefly present answers of students of natural, technical and computer sciences compared to answers of students of social studies and humanities and students of the department of elementary education. The latter will find special discussion in a different article but as the results are interesting, we will partially present them also here. Results of the Kruskal-Wallis test have shown that compared to students of social studies and humanities and students of the department of elementary education, students of natural, technical and computer science provided the most positive feedback for all statements despite the rather poor inclination. This means than among all students they provided the most positive answers about the availability of computers at the faculty, their performance, software, internet access at the faculty and internet access in the town of study.

The reasons why students of natural science, technical and computer science were more positive towards the conditions of using the computer for study purposes than students of social studies and humanities and students of the department of elementary education are probably different. Let us mention only two that we believe stand out the most.

The first is undoubtedly that despite similar capacities available to students (all three faculties are located in the same facility), the nature of their study allows students of natural sciences, technical and computer science to have additional and well equipped computer classrooms at their disposal that they can per agreement use also outside the time of the actual study process. With all this, we cannot neglect another important fact. The nature of the study at the majority of study programmes at the Faculty of Natural Sciences and Mathematics also means that a study without the use of the computer is virtually impossible. Already due to the nature of their study, students of natural, technical and computer science are more proficient in their computer knowledge and use of computers than students of the other two faculties. This might help them to be more inventive in the use of computers and computer equipment and it is therefore possible that they would evaluate the given conditions of using the computer at the faculty more positively.

Opinion of students on the necessity of using the computer in class and on the digital competencies obtained during their studies

We provided six statements and asked the students to mark their agreement with each statement using a five-stage scale. Their answers are presented in Table 2.

Table 2: Mean of Rating Scores[a], Standard Deviations and Rank Orders[b] of students reporting on the necessity of using the computer and competencies

Competencies	Mean	SD	Rang order
As a student teacher, it is essential that I am qualified to use the computer in class.	4.5747	.69269	1
Today, use of the computer in class is necessary.	4.0000	1.07833	2
As a student teacher, I have sufficient knowledge to use the computer in class.	3.8161	1.01762	3
I have clear ideas on how to include the computer in class.	3.7586	.77708	4
Use of the computer is essential in subject(s) that I will be teaching.	3.5747	1.26337	5
As a student teacher, I have sufficient knowledge to use educational portals in class.	3.1839	1.10526	6

[a]A higher score indicates that students expressed a higher level of agreement with an individual statement (1 = I completely disagree, 5 = I completely agree)
[a]A lower rank indicates that students expressed a higher level of agreement with an individual statement (1 = I completely disagree, 5 = I completely agree)

It is evident from the table that students expressed a more positive opinion on statements relating to the necessity of using the computer in class than on statements relating to their competencies for using the computer in class. They expressed the highest level of agreement with the statement that as student teachers it was essential that they were qualified to use the computer in class and that today, the use of the computer in class was necessary. They agreed less with the statement that use of the computer was essential in subject(s) that they would be teaching. This statement was ranked only fifth. Even though the students expressed a lower level of agreement with statements relating to their competencies for using the computer in class than with statement relating to the necessity of using the computer in class, their answers are still encouraging. They indicate that students are optimistic about the knowledge to use the computer in class while at the same time have clear ideas how to include computers in class. They are however less optimistic about the knowledge to use educational portals.

CONCLUSION

We can all agree that the use of computers in the educational process is becoming increasingly important if not even vital. As said in the beginning, the use of the computer in class brings numerous positive results. It needs to be stressed that classes involving the computer are more interesting to the students and if they have the opportunity to use the computer themselves, the obtained knowledge is stronger and more permanent. We however cannot neglect the negative side of excessive application of computers in class.

Due to the necessity of using the computer in the modern educational process, teachers no longer need only conventional competencies but also knowledge and competencies of using the computer in class. Teachers decide whether to enrich their classes with ICT and numerous factors influence the teacher's decision whether to use the computer in class. Preparing teachers to use the computer in class already during the teacher training programme, possibilities of accessing computers and the equipment available to students play a major role. All this can stimulate or weaken the motivation for using the computer in class.

This study established the situation in this field. As the research included a smaller sample, its results cannot be generalised to the whole population. The research is nevertheless useful, as it helped us see to what extent students were using the computer, their viewpoints on the conditions of using the computer at the faculty and the digital competencies obtained during their studies.

The opinions provided by the students of the Faculty of Natural Sciences and Mathematics do not fill us with optimism about the conditions of using computers at the faculty. On the contrary, the results of our research have shown that students believe that a lot needs to be done in this area, especially with regard to improving performance of computers and increasing the number of computers available to students for study purposes. The students further believe that internet access at the faculty and computer software need to be improved in the future.

The opinions of students of the Faculty of Natural Sciences and Mathematics on the necessity of using the computer in class leave us with more optimism. This especially relates to their beliefs on the importance of using the computer in class in the modern world of technologies and slightly less to the competencies needed for the use of the computer that they have acquired during their study. This is another field with room for improvement.

Finally, we wish to point out that the study included only students receiving their education according to the so-called old university programmes. The situation with students studying according to the so-called Bologna study programmes still needs to be researched. Teacher educators are those that can influence the quality of acquired competencies by using a good strategy, while modernisation of computer equipment relates to financial funds that we unfortunately cannot influence.

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AN ALTERNATIVE APPROACH FOR TEACHER EDUCATION COURSES FRAMED BY A COLLABORATE PARTNERSHIP SETTING.

Birgitte Schou Pontoppidan

Centre for Science Education, Aarhus University

bp@ivs.au.dk

ABSTRACT

The study presents an alternative didactical approach to teacher education linking practice and theory through *a collaborative partnership setting*. Using a "small scale" *teaching design* in which students alternate between schools and college it was possible to show some evidence that, by following this approach, first year student teachers in a science & technology class developed *teacher knowledge (as aspects of PCK).*

The study identifies an example using *Co-Re and PaPeR* as *a Resource Folio* to show where evidence of developing teacher knowledge is seen. This didactical approach turns the traditional teacher education on its head and begins with a focus on practice so students alternate between school–based and college–based teaching in a cyclical fashion, and are encouraged to link theory with practice. This kind of college teaching demands a new *teacher educational paradigm* for which collaboration between schools and colleges is paramount. This study indicates that a collaborative partnership setting involving college and *S&T- profile schools* can provide a "room for study", and that this kind of teaching design enhances the opportunities for students' to develop teacher knowledge (aspects of Pedagogical Content Knowledge) from the very start of teacher education.

INTRODUCTION

Linking theory and practice in teacher education is a challenge and international educational research has been dealing with this issue for many years. Partnership settings between schools and teacher education have been introduced to try and solve the problem (Furlong 1996).The Teacher Education programme in Aarhus (VIAUC) offers such collaboration, having developed partnerships with a number of training schools.

This study is a part of a larger on-going R&D-project concerning several approaches relevant to this partnership setting, and focuses on the possibility of offering "room for study", and so the opportunity for students to develop teacher knowledge, within the partnership setting. The aim is for the student teachers to be able to integrate college-based and school-based knowledge from the very start of their education in a way that makes it possible for them to develop the professional knowledge required for teaching, pedagogical content knowledge (PCK) (Shulman, 1986). However a collaborative partnership setting is a huge and complex frame for students, college teachers and mentors to work in, especially in a country like Denmark where there is little experience of this kind of set up in an education context. For there to be "room for study" within the partnership setting it will be necessary to develop alternative course designs for the student teachers, that provide suitable examples of didactical approaches so the student teachers have the opportunity to develop PCK as a result of the integration of college-based and school-based training.

This article sets out to provide an example of a possible design for such a teacher education programme that uses the partnership setting as “a room for study” within the collaborative frame.

Research question

Will there be evidence that an alternative course design framed by a partnership setting supports the students’ development of aspects of PCK?

I will begin by looking at what is actually meant by teacher knowledge in terms of PCK. I will then describe briefly the conditions of the partnership setting that are relevant for this case study. Next I will present a didactical approach to college-based and school-based teaching in the form of a course design that exploits the “room for study” in the partnership setting. Finally I will present some evidence that this approach to teacher education offers student teachers the possibility to transform different knowledge types by integrating college based and school-based learning and so start to develop PCK.

What kind of knowledge is the teachers’?

In traditional teacher educational settings teacher knowledge is believed to develop through the college-based and school-based teaching and training. The fields are usually taught separately and the integration into usable teacher knowledge has to a great extent been left to the student teacher’s own initiative. This has often proved to be difficult because according to the special teacher knowledge, ideas and theories that influence student teachers’ understanding of the link between theory and practice, this link is often tacit (Schön 1983, Korthagen 2001, Gess-Newsome 1999).

Teacher knowledge as PCK has been discussed in international educational research for the last twenty years (Berry et al. 2008), starting in 1986 when Lee Shulman (1986) defined special teacher knowledge as a construct of PCK that included,

“the most powerful analogies, illustrations, examples, explanations and demonstrations – in a word, the ways of representing and formulating the subject that makes it comprehensible for others....
…that special amalgam of content and pedagogy that is uniquely the providence of teachers, their own special form of professional understanding…Pedagogical content knowledge.... identifies the distinctive bodies of knowledge for teaching.. (Shulman, 1987, p.8)

After twenty years of Science Education Research teacher knowledge as PCK has been interpreted and elaborated by several researchers (e.g. Gess-Newsome, Appelton, Van Driel, Hashwey, Loughran, Abell). They have focused on different aspects of PCK, but there is a common opinion about four important characteristics of this kind of knowledge: PCK includes discrete categories of knowledge that are applied synergistically to problems of practice; PCK is dynamic, not static; Content (science subject matter) is central to PCK; PCK involves transformation of other types of knowledge (Abell, 2008, p. 1407). These four important characteristics of PCK and the synergistic view that PCK is more than the sum of its constituent parts will be the main analytical frame for this study.

As mentioned above teacher knowledge is a different kind of knowledge to its constituent knowledge types. Korthagen et al. (1999, 2001) try and make the distinction by referring to the knowledge types defined by the ancient Greeks such as Aristotle: Episteme and Phronesis. Episteme knowledge, in this context called theory with a capitol “T”, is based on research and the type of knowledge that is central to the field of teaching in traditional teacher education: Subject matter (e.g. biology), “Fachdidaktik”, Pedagogy. But more often student teachers need knowledge that is situation specific and related to the context in which they meet a problem, this type of knowledge is Phronesis, in this context named as theory with a small “t”, that is a more perceptual knowledge than conceptual (Korthagen 1999, p.7). So, teacher knowledge as explained above is theory with “t” with a foundation of theories with “T”, practical knowledge, Techne (praxis), and other things (e.g. ethics, emotions, tacit knowledge). All this is well illustrated by the “amalgam” metaphor (Shulman quotation above). Teacher knowledge is not a kind of knowledge that can be studied in a book, it is to be experienced and interpreted through reflections - in - action and reflections - on - action (Schön, 1983). Hashweh states that:

” We should stress....that PCK is knowledge associated with experience, and does not seem to develop from studying in pre-service teacher education programs, at least the traditional ones” (Hashweh, 2005, p 279)

Considering the knowledge types an alternative approach to teacher education would be to turn the existing college-based teaching approach on its head and start from practice and end in theory, as described in “The Realistic Approach to Teacher Education” (Korthagen et al. 1999, 2001, 2006).

“...the keyfactors is the relation between the schools in which student teaching takes place and the teacher education institute. Both staff based at the teacher education institute and cooperating teachers are part of one team that supports the professional development of student teachers” (Korthagen, 2001, p. 78)

Changing from a traditional teacher educational setting to an alternative approach, in which the focus has shifted to the students’ integration and transformation of different knowledge types requires the development of new content for the college-based training elements of the education programme. In addition it is important to consider the collaboration with the schools and the mentors as they will be the key to the whole approach as noted above (Korthagen, 2001). The conditions framed by a partnership setting will influence what opportunities student teachers have for transforming the different knowledge types into PCK.

The Partnership Setting

This Partnership setting is an agreement entered into by the training schools, the teacher training college and the municipality. In addition to the field experience period the partnership schools are obliged to involve the student teachers in other relevant activities including observations of teaching and pupils, parent meetings, staff meetings, school parties, etc. throughout the entire school year. The school-based mentors also have to take part in several meetings at the teacher training college during the year of study including planning meetings, and they are expected to take part in the preparations for the practical as well as the theoretical part of field experiences. Over all this partnership approach is very much in line with Furlong’s description of a collaborative partnership arrangement:

“For the partnership to succeed mentors and college teachers will need to plan some educational settings together in an ongoing collaboration to develop a programme for the student teachers that is integrated between college and schools “(Furlong 1996, p. 44)

However the didactical approach to the partnership setting is general and complex - one could describe it as “boulder size”, and one of the challenges will be to develop new approaches to the teacher training programme - at “grain size”. Teaching designs that have a “grain size” focus with an emphasis on the student teachers’ way of planning might prove to be a central issue for the partnership collaboration. Hashweh’s interpretation of PCK as a collection of basic units called Teacher Pedagogical Constructions (TPCs) is a reasonable framework for this kind of small scale teaching design (Janssen et al., 2008). Planning, according to Hashweh, is central to the development of TPCs and thereby to the overall PCK development.

“Teacher pedagogical constructions result mainly from planning, but also from the interactive and post active - phases of teaching” (Hashweh, 2005, p. 277)

This article presents an example of a small scale teaching design for college-based teaching, and is inspired by Janssen et al.’s 2008 study among others. Janssen et al. explored a domain-specific heuristic for lesson planning and showed the usefulness of cyclical processes alternating between school practice and college teaching.

It would be reasonable to assume that for first year students incipient PCK could start by developing TPCs or aspects of PCK. For this to happen the college-based teaching and the school-based teaching need to be integrated by taking advantage of small scale teaching designs that alternate between schools and college and offer the students an opportunity to develop teacher knowledge.

Resource Folio

Central to the teaching design is the use of a Resource Folio as a “tool” to help the student teachers bridge the gap between college-based and school-based teaching. The Resource Folio were originally developed by Loughran, Berry, Mulhall (Loughran et al. 2004, Loughran, Berry and Mulhall, 2006) as a method for exploring and representing expert science teachers PCK. The Resource Folio consists of a Content Representation, Co-Re, that represents the structured planning of the teaching and includes several points the student teachers must be aware of when teaching specific content (using knowledge about science and learners to make curricular decisions and using knowledge about science and learners to make instructional decisions) and a Pedagogical and Professional-experience Repertoire, PaP-eR, that is a complementary narrative which includes reflections on teaching. Together they are referred to as the Resource Folio (Mulhall 2003)

In this setting Co-Re is used in a slightly different way:
First as a “reverse engineering project” to make the students understand how to start building up aspects of teacher knowledge, drawing upon Subject matter knowledge (SMK), educational theories according to pupils learning, lesson planning, evaluation and so on. The elaboration of the Co-Re is meant as a basis for the further planning of the teaching sequence.

Second as a meta-theoretical approach to teaching, which was tried out by Loughran et al. (2008), who showed that it is possible to make student teachers aware of the existence of the different knowledge types in PCK.

Teaching Design

The design of the course outlined below shows an alternative didactical approach to college-based teaching in Science & Technology to enhance student teachers’ teacher knowledge. The topic is the blood circulatory system – a teaching sequence lasting for two weeks. The design alternates between school-based and college-based teaching and the different steps relate to the numbers in fig. 1.

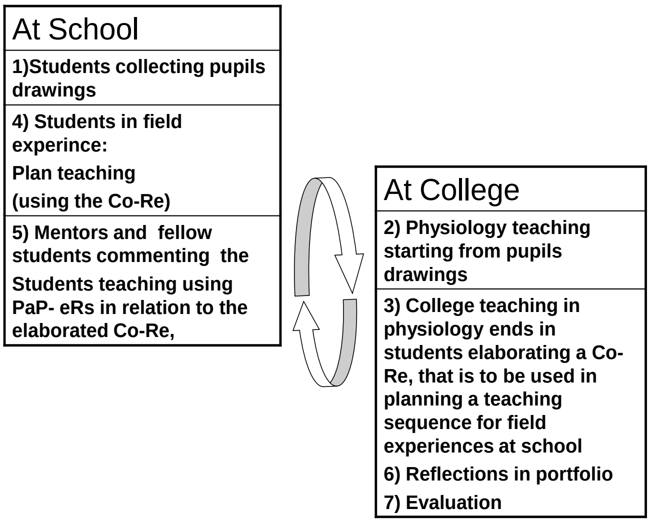

Fig.1, The cyclical process of the study alternating between college teaching and school practice.

1. The teaching sequence started in the school where the student teachers were supposed to identify some of the learning issues (Millar et al., 2006) that can arise when pupils try to understand their blood system. The student teachers asked the pupils, who ranged from 1st to 9th graders, to make a drawing of the circulatory system on a full size drawing of a body outline
2. The drawings were then presented and discussed at the college.
3. SMK according to the topic was taught at college, and the educational theories considered the drawings in particular in respect of the learning demands (Millar et al., 2006).
The student teachers' assignment was to plan a teaching sequence for Science & Technology that they could use in their up-coming field experience period. To be able to do this, the students had to elaborate a Co-Re based on a group discussion - the same group that they were to join for field experiences.
4. The next step for the students was to try out the teaching sequence during the field experience period. The students practice in groups of two or three and fellow students and mentors keep a diary as a narrative for reflection in the form of PaP-eR (Loughran et al., 2002) or portfolio.
5. An important part of the field experiences are the student/mentor conference meetings where the mentor discusses the students' reflections on their teaching sequences and the teacher professional competences they have demonstrated during the period. The mentors had agreed to give the students supervision in relation to the Co-Re. Mentors always keep a diary of the students' teaching if not a PaP-eR.
Theories with "t" are prevalent here.
6. Back at college the student teachers present the main points from their field experience period according to the Co-Re /PaP-eR reflections. The college teachers build upon the mentors' 'supervision by adding theories - mostly ("T") e.g. fachdidaktik, SMK and pedagogical theories.
7. The last part of the teaching design is for the students to reflect on the teaching in relation to the Co-Re at college after they have completed the field experience period. The students are supposed to write reflections in their field experience portfolios for the mentor and the college teacher to read and comment on. It is compulsory for the students to create this kind of portfolio, which has been selected as the overall evaluation tool in the partnership setting.

With this approach college teaching starts with the introduction of different kinds of theories ("T") from which the students can begin to elaborate the Co-Re. The elaborated Co-Re represents the discussed theories relating to the teaching sequence that the students are supposed to teach during the field experience period. The theories with little "t" are not relevant before the field experience as they relate to the student teachers' experiences, and therefore the Co-Re is meant to be corrected and commented upon during the field experience period. In this way the Resource Folio represents the connection, "bridge", between the college-based and school-based training - placed in the partnership's "room for study".

Methodology

This particular study deals with the teaching of human physiology, which is part of the "Science &Technology" segment (a STS-subject for pupils aged 7 – 12 years). The participants in the study are first year student teachers who have selected the Science & Technology class, and who will teach "the blood system" during their field experience according to the Co-Re elaborated during the teaching sequence at the college. Five students and three mentors were involved in this particular study. The rest of the Science & Technology class had other topics to teach during the field experience period and made a Co-Re related to this other topic, and will not be a part of this case study.

Because this teaching design has been developed during the college teaching period by the researcher herself, there is a need for a flexible research design (Robson, 2002). As a consequence the study has an entirely qualitative research design, and the data was collected from observations of student/mentor meetings, interviews with mentors and student portfolios – various methods were used to promote triangulation.

Table 1 summarizes the data collected and for which purpose: One observation with three students and two mentors and one observation with two students and one mentor. The mentors took part in a semi-structured interview (Kvale, 1997) after the observations. Both observations and interviews were audio taped and transcribed.

participants	Data source	Timing of data collection	Purpose
Students	Observation	March 2009 Weeks no. 12 -13	Prompts revealing types of knowledge and reflections
	Presentation	Week no. 14	Prompts revealing reflections using Co-Re and Pa - PeR
Mentors and Students	Observation	Weeks no. 12-13	Prompts revealing the student learning of teacher professional concepts by using Co-Re as the subject of conversation.
Mentors	Interview	Week no. 12 -13	Co-Re as a "tool" for collaboration in the partnership setting

Table 1 Details of data collection

In this study I am trying to elucidate if an alternative course design in a specific teacher education situation supports the student teachers' development of certain aspects of PCK, when framed by the partnership setting. The theoretical framework for analyzing the data is first of all the four characteristics of PCK identified by Abell (Abell 2008) as described above. But by taking the incipient PCK into consideration as well as particular aspects of the PCK, TPCs (Hashweh 2005) will also be part of the framework.

In this paper I am just trying to identify examples of where there is evidence of developing teacher knowledge (TPC or aspects of PCK). As there is still data to analyse, I have decided to focus on one student teacher to see what knowledge is being developed according to the analytical frame mentioned above.

From observation 1 I have recorded a conversation between student (A) and the mentor (X) that illustrates A's reflections on practice and developing TPC for the topic under discussion:

A: "…our goal is not that the pupils are supposed to describe the total blood circulatory system when we finish this topic. But they are supposed to know that the heart pumps blood and that we breathe. I know that we teach much more than this in class because it is meant for the bright pupils."

X: "There is no doubt that after the very intense teaching sequence about (digestion (prior topic)), where the pupils have been extraordinary interested and engaged they will not be able to show the same enthusiasm continuously. The heart dissection you made today did not have the same appeal though they were totally engaged in the dissection. But it was difficult for them to imagine how the blood is supposed to run through the heart because it is not there, and they can not see the heart pump. That might be the reason why the pupil engagement was not as great as during the last topic"

A: "That is what I am reflecting upon. Perhaps this topic should be for 5th – 6th form instead - but the curriculum states that it ought to be 3rd – 4th!."

X: "You could probably break the goal up into minor parts?"

A: "Yes it should only be simple things to support the pre-conceptions. I will try to reduce this before the next lesson. Perhaps we should rethink our Co-Re"

(A) has obviously experienced that theories "T" and preparation based on these do not always fit with the reality, and neither does the curriculum. It also shows the reflection process that makes A rethink the planning because of the learning demands connected to this topic were different compared to another previously taught topic.

(B)

The conversation shows the usage of theories such as SMK, fachdidaktik and professional knowledge on the basis of experience. Though it is experience shared with the mentors and the fellow students, student A shows the ability to reflect upon his planning (referring to correcting in the Co-Re), which is one of the criteria for TPC development (see Hashwey quoted above). A also shows the ability to reflect upon a teaching sequence using theories "t".

A ends this particular conversation by saying:

A: "It has been a good "discussion platform" e.g. this discussion about the different hearts (animal types). One can make mis-judgments about the children's ability for learning the subject in a certain way but the Co-Re made us focus on the theories of Piaget and discuss the dilemma of the demands from the curriculum – so now we refer to Vygotsky and we will see when the pupils have made the last drawings (evaluation tool *ed.*) if we have been scaffolding enough."

This prompt illustrates that he is able to integrate Theories "T" as well in his reflections. He demonstrates that he is capable of meeting the four important characteristics of PCK (Abell 2008)

(The relation between the outtakes from the conversation to the noted characteristics is bracketed):

- Discrete categories of knowledge that are applied to practice *(SMK, curricular knowledge and pedagogy are applied in the reflection on practice).*
- That PCK is dynamic *(The corrections of the CoRe and after initially referring to Piaget he then finds Vygotsy's theories more appropriate).*
- That Content is central to PCK *(Previous topic easier for pupils to understand than the blood topic).*
- PCK involves transformation of other types of knowledge *(Theories with "T" and "t" have been reflected upon in the dialogue with the mentor).*

The two mentors are recognizing the Co-Re planning and X mentions in the interview afterwards that he thinks it is suitable to collaborate within the partnership setting between school and college:
(From the interview guide)

"Do you think it is worth proceeding with the work with Co-Re and PaP-eR as collaboration between college and schools?"
X: "Very good tools and it might be possible to make it "more Danish". As a part of the college teaching it is perfect because you can also use it when the education is finished and you have well planned and reflected teaching sequences in your "bank"."

CONCLUSION

What I was looking for was a new didactical approach to college teaching - that is well suited for collaboration between schools and college using the partnership setting as, figuratively speaking, a "room for study" and somewhere for the student teachers to begin developing their PCK. The idea was to concentrate on a "small scale" teaching design making it possible for first year students to have a chance to begin building TPCs or aspects of PCK as a basis for further PCK development during the rest of their education and in their practice as teachers.

Though I was only able to use selected conversation segments from one student teacher to show there is evidence of developing teacher knowledge, these excerpts seem to support the main idea in this article: That the use of Co-Re and PaP-eR in a "small scale teaching design" that alternates between college and schools might be a way to enhance student teachers' development of aspects of PCK. This kind of college teaching requires the evolution of a new teacher education paradigm, as it turns the traditional approach to college teaching on its head. By linking theory with practice, so that the initial focus is on the practice gained as the student teachers circulate between college and school experience site teacher education could be improved considerably. There are indications in this study that a collaborative partnership setting might constitute a "room" for this kind of teaching design and thereby enhance the students' development of aspects of PCK – collaborative partnerships could therefore be considered as a "room for study".

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CONSTRUCTING PHYSICS EDUCATION IN DIFFERENT CONTEXTS: CHANGING CONTEXTS – CHANGING VALUES

Oleg Popov
Umea University
oleg.popov@matnv.umu.se

Thongloon Vilaythong
National University of Laos
thongloon.vilaythong@physics.umu.se

ABSTRACT

This paper presents an analysis of how changes in the socio-economic context of an educational system affect the value base of the physics education embedded in this context. Based on the assumption that physics education is a socially constructed phenomenon developed within a particular socio-historical context with particular types of social relations, this study aims to highlight the features of physics education that are most sensitive to changes in the macro-context. In this paper empirical material was gathered from two countries (Laos and Russia). In both countries dramatic economic changes have taken place since the end of the 1980's, however, Laos has maintained the same one-party rule political system while the Russian political context has changed significantly. These countries also belong to the different cultural contexts of East and West, the consideration of which can contribute to an understanding of the corresponding value-base reflected in physics education. The qualitative research methodology used in this study includes data gathering through document and statistical report analysis, personal ethnographic experience and interviews with physicists and physics educators. It is argued that changes in educational values are not only discussed and experienced but actually created within physics education institutions in these countries against the backdrop of the macro-contextual changes taking place over the last twenty years.

Keywords: *Laos, macro-context, physics education, Russia, values.*

INTRODUCTION

The issues of developing human capacity and increasing the scientific capital of countries are actively discussed by politicians and academics around the world. Many countries have as a strategic goal the development of a knowledge-based society. The governments make investments in the creation of a critical mass of researchers in specific scientific fields. Universities also purposefully invest in building up research schools and creating successful research niches. Different countries have different traditions and conditions for promoting academic and applied research in certain fields. For example, the Soviet Union has been a real "science powerhouse" with a very high status in science from the time of the launching of the first Sputnik satellite. Many bright physicists and mathematicians were fostered there. Just to give an example, two out of four Fields Medal (considered to be the Nobel Prize of mathematics) laureates in 2006 were Russians, one graduated from St Petersburg University (Perel'man) and one from Moscow University (Andrei Okoun'kov). Both of them had been actively working in the field of theoretical physics and valued highly the importance of 'physics thinking' for their achievements in mathematics (ICM, 2006). They were brought up in the well organized Soviet system of physics and mathematics education that fostered solid science knowledge and creativity, particularly in gifted children.

However, educational institutions and researchers do not operate in a vacuum. People's choices, values and motivation depend as much on their working and living conditions as on the status and respect they are afforded by society. Grigori Perel'man, who was awarded the Fields Medal for solving the famous Poincare conjuncture, declined the medal and substantial economic award as a protest against the current situation in science in modern Russia. Dramatic changes in the Russian society in the period after perestroika led to new political priorities and economic conditions and as a result to new values and aspirations for society. According to a survey study conducted in 2006, to be a scientist in Russia today is regarded as one of the less prestigious professions (Adams, King, 2010).

The post-Soviet changes of the 1990s affected not only the Russian academic system but that of many countries around the world. In a review of national research systems in developing countries, Mouton and Waast (2009) show that research is no longer seen as a rewarding career there. The adoption of 'liberal' economic policies in poor countries, under the oversight of the International Monetary Fund, has led to restrained state spending in social and non-productive sectors. Researchers find it almost impossible to make a living and support for their immediate families. They have to take extra jobs unrelated to their research, undertake overtime teaching, or search for work in richer countries. Mouton and Waast (2009) suggest that the restoration and improvement of national research capacity in these countries requires a strategy that focuses on institution-building interventions rather than on individual scientists. Such strategies have been successfully implemented in some Asian countries. The Eastern cultural tradition of nurturing collective development has proved to be effective for promoting a rapid expansion of research. Governments that pay attention to national scientific capital also pay their researchers well. However, such factors as the power of trade unions, type of economy, cultural and intellectual traditions and the capacity of educational system cannot either be neglected. A country's investment in scientific research is usually paralleled by an investment in science education.

The hypothesis that we would like to explore in this paper is that changes in national economical and socio-political contexts strongly affect societal values, the production of scientific research and the construction of science education in the country. This hypothesis will be examined in the case of the two authors' native countries Russia and Laos and the focus will be on our professional field of physics education.

THE ACTIVE ROLE OF THE CONTEXT

Context plays an important role in peoples' lives. There are embedded background assumptions in everything that people do or say that are discernable only through the context. It is possible to state that human intelligence is context-sensitive. Researchers like Russell (1992) claim that context is of such importance in epistemology that there can be no inference or knowledge without it. It appears to be a basic building block of knowledge and its processing. It can be argued that without context there is no knowledge or knowledge processing (Russell, 1992).

The problem with context is that there is as yet no universally accepted definition, nor any comprehensive understanding of how to represent it or how it affects knowledge processing. A context consists of a set of things with specific and consistent relationships between them. The Latin root of the word context, *contexere* means 'to weave together' or 'that which gives coherence to its parts.' The relations and events that actually comprise a context can only be revealed by experience. Context is an open-ended and unbounded thing that according to Russell (1992, p.323) obeys a Heisenberg Uncertainty Principle and the act of perceiving it changes it. He underlines the importance of considering the depth and uncertainty of context in the analysis of human behaviour. Shanon (1983) suggests that context should be regarded as an interface element between the internal and external worlds.

Vygotsky (1978) considered context to be an active component of the educational process that interplays with learners' and teachers' activities. We suggest that the role of the context in constructing physics education can be considered at three levels: micro (individual teacher / classroom), meso (institutional) and macro (supra-institutional, national). At micro level, a teacher constructs learning environments that shape students' learning and the students can actively influence these environments. At institutional level (meso) decisions are taken that shape the curriculum work of individual teachers. Socio-cultural and politico-economical factors at macro level influence all subordinate levels and this level will be the main focus of further discussion. Macro context is also related to national culture.

The individual and the context mutually recreate each other. Each person is not just an observer but also an actor. We assume that context plays an important role in constructing and re-constructing physics education and can provide a frame of reference for the analysis of curriculum values.

RAISING INTEREST FOR CONTEXT IN PHYSICS TEACHING AND LEARNING

Looking at the development of physics education from a historical perspective it is possible to note that discussions about teaching/learning physics before the 1960s were mainly focused on *content* and later shifted to *process* dimensions using a student centred approach. Recently a general agreement has been achieved that the *context* dimension is very important for the design and implementation of the physics curriculum. Currently, physics teachers and researchers experiment broadly with the use of different contexts in the organization of learning activities. For example, physics investigations can be implemented in a variety of outdoor settings such as schoolyards, playgrounds, gardens, and amusement parks (Nilsson, Pendril, Pettersson, 2006). The methodology of physics field experiences in urban environments and "natural" areas is described by Foster (1989) and Popov (2008).

The use of historical contexts and the replication of pioneering experiments in physics can demonstrate genuine methods of scientific discovery (Heering, Osewold, 2007). Arthur Stinner (http://home.cc.umanitoba.ca/~stinner/) from the University of Manitoba in Canada developed a contextual approach to teaching physics called the Large Context Problem (LCP) approach. This approach is based on the assumption that learning could be greatly motivated by a context with one unifying central idea capable of capturing the imagination of the students (Heering, Osewold, 2007). Harvard professor of physics, Eric Mazur and the physics education research group at the University of Minnesota have developed a "rich context problems" approach for collaborative learning. Real world contexts from the students' lives outside school have the potential to generate personal interest in science. A comprehensive overview of research on different methods of using real-life context for improving physics learning has been made by Cahyadi (2007). Researchers from York University (UK) have been working with context-based approaches in science teaching for many years. They found evidence that such approaches motivate pupils in their science lessons and foster more positive attitudes to science (Bennett, Hogarth, Lubben, 2003).

Fencham (2009) discusses the role of the OECD's PISA project for the assessment of scientific literacy among young people for the renewal of interest in context-based science education in different countries. The methodology of the PISA approach was to assess how well 15-year-old students' science knowledge, from whatever source, can be applied to the situations involving science outside school that increasingly confront citizens. The emphasis was on the students' ability to actively use knowledge in new situations. Fencham (2009) talks about 'Context as a Source of Scientific Competence'. The difficulty or ease that students have in answering contextual questions may be due to the context itself (more or less familiar, more or less interesting, more or less relevant) or to the types of questions. However, the PISA project focused only on scientific knowledge and scientific competencies that are pragmatically useful. Sjøberg (2007) argued that this focus neglects other values science has for scientists and for the public such as, for example, creating a sense of wonder about the natural world and the mystery of the universe itself. How this ‘‘sense of wonder’’ can be incorporated into school science curricula remains a challenge.

These works and other recent studies recognise the importance of considering the roles played by the contexts (in micro, meso and macro levels) in constructing and re-constructing physics education, in designing, implementing and achieving physics education curriculum.

CONSIDERING THE CULTURAL CONTEXTS OF EAST AND WEST

Studies of how cultural aspects influence physics education are currently becoming popular, in particular in Asian countries (Pak, 2004). The exploration of the cultural dimensions of the macro context is interesting in this paper as Laos belongs to the Eastern cultural context and Russia officially identifies itself as belonging to the Western cultural context.

According to Jarvis (2009), there are profound learning differences between people from Confucian heritage countries and those from the West. The human brain is social. We are all nurtured in our own national culture. “The culture of a country affects all aspects of the life and thought of the people living there. Like the presence of the atmosphere, it is difficult for people who were born and have grown up in the midst of it to be conscious of. They take everything in their culture for granted; most of them go through their lives without realizing that there can be other ways of living or doing things” (Suzuki, 2001, p. 30).

Jarvis (2009) states that human cognition is not the same everywhere. In the West it is more likely to be individualistic and in the East more communitarian. A major strength of group culture is that individuals are members of a group and are bound by their unity. Within the group individuals are cared for because they are part of the group. The group generates a stronger sense of group solidarity and places more emphasis on the person’s responsibilities to the group or sub-group. However, an emphasis on group culture can be very divisive since each group seeks to create its own boundaries and to protect them against other groups. Considering communication patterns, in- and out of group relationships and social hierarchy are two important dimensions clearly visible when people articulate and express themselves in the presence of other people.

In the West, individualism dominates over group interests. It appears that the individual is more significant than the group. The ideals of Western political and social systems based upon the individual are promoted around the world through mass-media and research communication. Woodrow (2001) talks about ’the imperialism of individualism’.

Western physics education research is often an individual teacher/researcher based enterprise e.g. action research models or design research implemented by an individual teacher in the classroom. Eastern educational research is usually collective work targeting institutional development, rather than the improvement of the work of individual teachers. An illustrative example of Eastern educational research can be “Lessons Studies” in Japan which is the most common form of practical research and capacity building activity in schools. Thus, most educational research publications in Japan are produced by practicing teachers/teams of teachers that present the results of their collective activities (often generated through “Lesson Studies”) oriented towards the improvement of their educational institutions.

Eastern thinking and behaviour is more context and situation sensitive and more clearly related to personal feelings (to the heart). Pak (2004) suggests that traditional Eastern thought is based on connectionism and holism. No individual or unit can exist without connections. “I connect, so I am”. These cultural context characteristics, complemented and validated by our own experiences of living and working in Eastern and Western countries, are summarised in table 1 below.

Table 1 Cultural-context features of learning environment in East and West

East	West
Communitarian	Individualistic
Hierarchical relations within group	Flat organisation of group collaboration
Respect for those who know, for elders, for men, for superiors, strong group loyalty	Freer way of expressing own opinions without age and gender considerations, weak group feeling
Sensitive to ‘loosing face’	Anyone can make mistakes
Unease when working together with strangers	Focus on task not on people, more tolerance for group settings
Detailed discussion to reach consensus, avoiding confrontation	Groups are open for debate, argument and confrontation.

Our experience also confirms data from the literature that gender patterns of behaviour differ between the East and the West. These include spoken and body languages, ways of making eye contact and taking the initiative, expressing opinions and presenting arguments.

The cultural characteristics of learning and behaviour in East and West have certain implications for shared curriculum values in educational systems belonging to corresponding parts of the world. We attempt to present them in table 2 below.

Table 2. Cultural implications for curriculum values in East and West

East	West
Teacher has authority and leadership	Learner has autonomy and self-determination
Focus on ‘bodies of knowledge’	Focus on individual voyages of discovery
Transmission model of teaching	Interactive teaching
Teacher has responsibility for learning outcomes	Learner has responsibility for learning outcomes
High value of the utility of learning	High value of enjoyment in learning
Habits of hard work/studies	Appreciation of combined work & leisure activity
Preference for quiet learning environment & everyone doing the same	Preference for peer-interaction & individual choice

We suggest that it is important to bear in mind these culturally bound characteristics when analysing changes in physics education in countries belonging to different cultural contexts.

THE PURPOSE OF THE STUDY

First, a brief analysis of the recent social changes in Laos and Russia is made based on data collected in and about these countries. Then the study elucidates shifts in societal values faced by the researchers and university physics teachers in the two countries. The analysis explores how these values influence people when they make choices concerning their university studies and professional career opportunities.

The following research questions were formulated

- How do changes in the socio-economic context of an educational system affect the value base of the physics education embedded in this context?
- What are the features of physics education that are most sensitive to changes in the macro-context?

- Are there cultural characteristics that influence physics teachers' and students' academic work?

By elucidating these issues we hope to better understand the challenges faced by physics curriculum actors in the two countries.

METHODS

Working from the perspective that physics education is a socially constructed practice, the research issues raised in this study dictated a need to use a qualitative approach. Qualitative research seeks to understand things in context as socially located and historically developed phenomena (Silverman, 2003). Data was collected through the analysis of literature, conference presentations (in particular, at the Physics in the System of Modern Education conference, in St Petersburg, June 2009) and media sources as well as semi-structured interviews with 3 faculty staff at the National University of Laos (NUOL) and 4 physics educators in Russia. The Google search engine was used for the initial collection of information. Then, data was subsequently screened and controlled through the analysis of original sources of information or compared with data presented on official websites such as the Russian Academy of Science (www.ras.ru), UNESCO and other international organisations.

Convenience sampling technique was used to select interviewees. Authors contacted physics educators they knew from previous academic collaborations. An important selection criterion was that the participants should have more than twenty years of professional experience of teaching and doing research in physics. An interview guide was constructed and pre-tested, focusing on the subjects' experience and opinions about contextual changes affecting the quality of teaching-learning physics at universities from a modern historical perspective. Face-to-face interviews took place in Vientiane, Moscow and St Petersburg in Lao and Russian languages correspondingly. Notes were taken and an mp3 recorder was used to record the conversations during interviews. Before the interviews, all the interviewees were asked for permission to record. The duration of the interviews was on average thirty minutes. Field work and data collection took place during 2009.

The findings were identified and organised in text form without preliminary transcription of the audio-recordings. The texts were shared between both authors and discussed in order to assure the reliable treatment of data.

No separate ethnographic study was conducted as both authors have had experience of doing research and teaching physics at undergraduate level in these countries. Consequently, their autobiographic narratives were used as a source for the triangulation of the findings of the study.

FINDINGS: THE INFLUENCE OF THE CONTEXT ON EDUCATIONAL VALUES AND CHOICES

The case of Russia

When describing the changing situation of physics education in Russia, we need to gain an insight into the soviet socio-cultural context and the historical roots of scientific traditions and successes originating from the soviet time. When people do not have external freedom, as for example in a state system of strict subordination and prescribed behaviour and lifestyle, they seek internal freedom. In the USSR many creative and independent people chose to study physics and mathematics, where there was less interference by the state. The creative freedom of working with physics research was also combined with a high social and economic status. However, many physicists worked hard not for the money, but for personal cognitive satisfaction, social respect and for the benefit their work gave the country.

Well established research schools existed in many universities and academic centres around the country. The biggest research centres also had specialised physics and mathematics boarding schools for gifted children. A system of physics and mathematics Olympics and other competitions were created and a methodology of working with gifted children was developed. Universities had physics and mathematics clubs where students under the guidance of professors worked with children for a couple of days a week. Summer physics camps and physics (technology and astronomy, aero- and radio modelling) circles of non-formal (out-of-school) education existed in every small town.

To create something takes a long time but unfortunately destruction can be very rapid. This is precisely what happened with the science centres and boarding schools after the USSR's self-abolishment; many of them quickly disappeared. Work opportunities for physicists in Russia also shrank dramatically with the dismantlement of the military industry and the closing down of "industrial branch research institutes". So, many thousands of researchers lost their jobs in a very short period of time. Furthermore, the rapid erosion of scientific activities was caused by insufficient state funding, privatisation research infrastructure, emigration and internal migration of scientist to private businesses. The state funding of science has been reduced 20 times since beginning of the 1990s (www.ras.ru).

As a result the number of scientists and male professors in the most productive age of 30-45 years diminished drastically in all academic institutes around the country. One of the interviewees mentioned that currently at Moscow State University (MGU) less than 20% of the professors at the Faculty of Physics (out of 250) are younger than 50 years. The average age of professors in Russia has increased by more than 10 years in the period after the perestroika. Russian physicists and physics educators are aging rapidly. In general, teaching staff in all educational institutions are overrepresented by elderly men and women and in schools mainly by elderly women of about retirement age. This is also understandable as salary level increases according to length of employment. Thus, elderly people are relatively better paid.

When young people choose to study physics they normally aspire to an international career or to work for big private companies within the petrol industry as their dream employment. In the post-soviet period physics studies became popular with an additional specialisation in English. This opened further opportunities for the students to work abroad or to search for employment with foreign companies operating in Russia. Since the early 1990s more than 80,000 of the most dynamic Russian scientists have left the country (Adams, King, 2010), with the total emigration of scientifically skilled labour amounting to over half a million people (BBC, 2002). In the period between 1990 and 2002, the number of people involved in research and other academic activities decreased by 55.2%. In absolute figures, this means that Russian science has lost 1,072,500 skilled people (UNESCO, 2005).

In many branches of physics, scientific productivity is directly related to the amount of time spent in the laboratory. According to one interviewee, in the old days, the main manpower in laboratories was students in their final year and doctoral students. Nowadays, these people spend much of their time outside the research institutions trying to make extra money. Laboratory facilities are also dilapidating. Only the strongest universities have been able to get some state grants to upgrade their material infrastructure in recent years. There is also a significant decrease in the numbers of students applying for physics studies at undergraduate and post-graduate levels. At the same time, over the last fifteen years 3,200 private institutions of higher education and their branches have begun to operate in the Russian Federation along with new branches of existing state universities. Most of them specialise only in the social sciences and humanities and attract significant numbers of young people.

The Russian physicists interviewed suggested that the period after *perestroika* was characterised by a steady destruction of physics education in the country. The system of formal and informal physics education was dismantled on all levels due to a lack of state funding. Currently, major curriculum changes are also being implemented by the government. Astronomy has been taken out of the compulsory school curriculum and is gradually being 'substituted' by the study of religion. The Russian Orthodox Church actively promotes a Bible-based view of the world as an alternative to the materialist worldview. The country is going through the process of active clericalisation and the substitution of the knowledge accumulated by science with faith.

The time allotted for physics studies is being reduced at all school grades. The recent introduction of a national Unified State Examination, known in Russia as *Edinyi Gosudarstvennyi Ekzamen* (EGE) led to changes in teaching methodology. The exam consists of three parts: part A contains multiple-choice questions; part B consists of one-word, fill-in-the-blank questions; and Part C where students are required to write their own solutions to problems or a composition. This exam has a selective character. It is taken by students in grade 9 for admission to high school and in grade 11 for admission to university. It was introduced on an experimental basis from 2001 but since last year it has been implemented all over the Russian Federation. The physics educators interviewed expressed concern that EGE makes teaching in schools oriented not towards understanding but towards passing the exam.

According to the interviewees, additional complications for the survival of physics education in the country were created by the Russian government when it decided to join the Bologna process. Only military and medical universities are exempted from the Bologna model of 3 years Bachelor followed by an additional 2 years Masters education. For all other professions, including physicists and engineers, a two-level system has been introduced and the Masters level will be self-financed by the universities. In practice, this means that it will be accessible only for a small number of students whose parents can afford to pay for studies at Masters' level.

Russian physics teachers and researchers talk proudly about the many bright students that they have had and still have now in their departments. "Sources of talents are inexhaustible in Russia". They narrate stories about their graduates working at different universities abroad or successful businessmen, stock exchange analysts, bankers, owners of construction and other companies in Russia. They emphasised the social importance of developing a physicist's way of thinking: analytical capacity, solid knowledge, schooling in perseverance and problem solving skills that make physics education so valuable per se. However, most of them also expressed bitter feelings that Russian physics education is in worse condition now than twenty years ago, and that they cannot foresee a significant improvement of the situation in the near future.

The case of Laos

Physics and physics education research is currently in a phase of germination in Laos. Research and development projects are run with the help of foreign donors and in collaboration with universities from neighbouring countries and overseas. Four physics lecturers from NUOL are involved in a PhD programme in Sweden (two of them in didactics of physics) and masters' programmes are also being made available, locally and abroad, for new staff.

The university system in Laos was transformed following general socio-economic transformations in the country in the early 1990s. In this period the country faced economic problems as a result of the discontinuation of support from the Soviet Union, a restructuring of the world markets and the process of economic liberalisation. Many foreign investors came to Laos. They opened new businesses that demanded competent local people. This resulted in a rapid brain drain from the university. Some academic staff and in particular good physics lecturers moved to businesses, foreign projects and international donor agencies, or climbed up in the university administration hierarchy thus abandoning practical teaching. Some physics lecturers utilised the new opportunities and went to study in more developed countries in the region and in the West. Thus, the competence of teaching physics in particular its practical-experimental component dramatically decreased during this period.

When discussing the motivation to study physics from a historical perspective, teachers commented on a visible trend of decreasing interest in the study of physics in Laos. Before the 1990s, scholarships were available for all students (higher education was fees-free) and most of the students got a teaching job after graduation. When the students entered into physics studies they had secure work prospects and a clear picture of future opportunities. This picture is rather more diffuse for the students who enter into physics studies today.

Currently, the student selection process to undergraduate physics education in Laos is based on ‘the rest goes there’ principle. After failing national entrance examinations and examinations to the more prestigious faculties such as Economy, Medicine, Law, etc young people take their last chance at the Faculty of Science. If they pass the admission exam to this Faculty they have to choose between different specialisations, i.e. Computer science, Biology, Mathematics, Chemistry, and Physics. The most popular is Computer sciences, followed by Chemistry and Biology, with the last choice for most students being Physics. So, the Physics programme is a kind of ‘last resort’ (least desirable) for the students. Physics attracts almost ten times less students than computer sciences. As an interviewed lecturer commented: *All our students want to study at university but can only get in to Physics. Only 5-10% of them (students at the Physics Department) are interested in studying physics*.

In general, lecturers commented that not many students attempted to study hard. They came to classes without preparation, copied homework from each other, missed classes, etc. At the same time the lecturers did not show much diligence in controlling how students do their studies either. Often, lecturers had extra work in 2-3 places outside the university in order to provide additional income for their families. Private tuition in their subject areas was the most common activity for university teachers. Some staff also engaged in different consultancies and opened small private shops, such as photocopying and digital printing. As a consequence these activities limited the time available for ordinary duties at the department.

Currently, the Laos government has started to make statements about the importance of nurturing talents in the country. A school for gifted children was built up and opened in the capital Vientiane. It is a symbolic gesture marking the political awareness of valuing national scientific capital development. The only PhD in physics at NUOL, the Head of the Physics department, was appointed as a vice-principal of this school. The school specialises in science and mathematics education. The government has promised to provide better salaries, modern experimental and ICT equipment for the teaching staff. The current situation with regard to physics education in Laos is discussed in more detail in the paper by Popov and Vilaythong (2009).

DISCUSSION

In Laos and Russia, the current shifts in the socio-economic context from a socialist to a new capitalist structure with corresponding shifts in values from a collectivist to ego-centric consumerist perspective have influenced the self-interest of individuals. This is reflected in their desire for a quick and stable economic return on their educational investments. Physicists, mainly employed by the state in both countries, cannot count on a high income after graduation. As a result, the context at local and national levels does not stimulate an interest in studying physics as a poor state budget cannot guarantee a decent life for university physics teachers, researchers and physics graduates. To be a physicist is no longer an attractive profession in both countries.

Adams and King (2010) in their analysis of research and collaboration in Russia conclude that the country has been a leader in scientific research and intellectual thinking across Europe and the world for so long that it comes not only as a surprise but also as a shock to see that it now has a small and dwindling share of world activity as well as real attrition of its core strengths, notably in physics and space science. The problems faced by people in the pure physics research field are even more acute in the field of physics education. For example, laboratory equipment in schools and universities has not been upgraded for decades. State production of such equipment became privatised, prices for locally produced physics instruments soared, so consequently not many consumers can afford it. Thus physics education is becoming less laboratory focussed. The practical component in education suffers first when unfavourable changes for science development take place in a national context.

Russian professors have one of the lowest salary levels in the world, comparable only with some poor African and Asian countries such as Laos. Old professors are trying to maintain traditions of high quality in teaching but they experience less support from younger assistants and notice a significant lowering of students' knowledge as admission criteria for physics studies are dropping.

The proliferation of private higher education institutions becomes a problem in many countries around the world as the expansion of the student population leads to a lowering of educational standards. This has also become the case in Russia and Laos. "It can be argued that the enormous number of newly created universities and other institutions of higher learning represent a loss for Russian science and academia." (UNESCO, 2005, p. 139).

Physics education in Laos has changed less than in Russia, as the initial situation was very different. Using the words of the French philosopher Jean Baudrillard (1929–2007), it is possible to talk about 'simulated physics education' in Laos, when teachers pretend that they teach physics and students pretend that they learn. In this way physics students can obtain a diploma of higher education that opens employment opportunities for them in fields others than physics.

The Russian situation exemplifies how the macro level contextual changes have led to a shift from collectivist to individualist values in society and educational system. According to Feigel'man (2007), society has been atomised into a collection of weakly interacting individuals. This can also be interpreted as general shift from an Eastern to a Western ideology of education. The new generation of Russian educational researchers and administrators eagerly adopt Western fashionable theories and approaches neglecting scholarly traditions developed by generations of talented physics educators in the country. A corresponding shift in teachers' priorities is also visible through the exclusion of more resource-demanding and time consuming components from the physics curriculum and the transfer of responsibility for the outcome of studies to the students. An individualist approach and the principle of the survival of the fittest have become dominant in the educational system.

The individual and the context mutually recreate each other. The context is not just the surrounding environment observed by an individual but it is also created by him. Each person is not just observer but also an actor. However, as one of the Russian interviewees commented, Russian society is developing a habit of living without science. The past achievements of soviet science tend to be forgotten by the general population and even unknown for younger generations. Modern scientists do not represent 'professional and human models' for Russian youth, as they do not see the scientist as a respected profession in society. A materialist approach and scientific worldviews tend to be presented in the media as archaic and belonging to the communist past. Societal values are changing with changes in the macro-contexts and this affects the status, functioning and prospects of science and science education in the country. In conclusion, we can say that in spite of different points of departure it is possible to trace similar trends in the development of physics education in Russia and Laos that are caused by similar contextual changes.

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EXPLORING THE RELATIONSHIP BETWEEN SUBJECT MATTER KNOWLEDGE AND REFLECTIVE PRACTICE AMONG PRESERVICE SCIENCE AND MATHEMATICS TEACHERS

Gorjana Popovic

Illinois Institute of Technology

popogor@iit.edu

Allison Antink

Illinois Institute of Technology

aantink@iit.edu

ABSTRACT

This study explored the relationship between preservice science and mathematics teachers' subject matter knowledge, pedagogy, and pedagogical content knowledge through the lens of reflective practice. Three preservice teachers participated in the study. Two course instructors (mathematics and science) used microteaching experiences during a method's course as a context to explore how the concurrent development of pedagogical skill, pedagogical content knowledge and subject matter knowledge were influenced by reflective practice (Schön, 1983). Self-reflection questionnaires, videos of microteaching and lesson plans were each used to develop a case study of each participant. Suggestions for future research are also discussed.

Keywords: *Pedagogical content knowledge (PCK), pedagogy, reflective practice, science teacher education, mathematics teacher education.*

INTRODUCTION

According to the Professional Standards for Teaching Mathematics (National Council of Teachers of Mathematics, 1991) one of the crucial factors in teachers' professional growth is the extent to which they "reflect on learning and teaching individually and with colleagues". We agree with this position and believe that it is important to provide preservice teachers with opportunities to reflect on their own teaching. There is a significant body of work that supports the value of teacher reflection but the following study is unique among them for the lens that is used, content knowledge.

This study is the first in an ongoing exploration into the relationship between pedagogical content knowledge (PCK), pedagogical knowledge (PK), content knowledge (CK) (Shulman, 1986) and the reflective practice (Schön, 1983) of preservice teachers. Ultimately, this paper characterizes the PCK, pedagogical understandings and reflective practice of preservice mathematics and science teachers given differences in content knowledge. The current aim, therefore, is to describe the similarities and differences in their reflection on and enactment of feedback related to these domains of teacher knowledge. The following questions guided this study: How do reflections influence changes in teaching practice among teachers with varying degrees of content knowledge? And, what is the nature of the changes that take place?

BACKGROUND

Three preservice science and mathematics teachers, Oscar, Yvonne, and Erica are described in this study. Each of them completed both microteaching and reflection questionnaires as coursework during an introductory methods course. Microteaching is practice for preservice teachers to design and implement a lesson with their peers acting as a “class”. The methods course was embedded within a combined masters degree and secondary certification program at a private, midwestern university and was designed for the simultaneous inclusion of both mathematics and science teachers.

At least two days prior to each lesson, the preservice teachers submitted a detailed lesson plan to both course instructors. The lesson plan included objectives, activities and assessments as well as a detailed script of possible student questions that may arise during implementation along with potential responses. Following the implementation of the lesson, each teacher shared their impressions of the strengths of the lesson as well as their impressions of the difficulties students might encounter if participating. Both course instructors then shared pedagogical and content specific comments and concerns. The lesson was video-recorded and a copy was given to each teacher. They were asked to watch their lesson at home during the following week and to respond to a questionnaire eliciting their perceptions of the strengths and weaknesses of their design, delivery and facilitation of any activities. In particular, they were asked to respond to following questions:

1. Please describe three things that went well during your lesson and explain why?
2. Please describe three things that did not go well and explain why?
3. If you could teach this lesson again what you would do differently? Explain why.

The questionnaire was open-ended and the preservice teachers were asked to be as detailed in their responses as possible.

METHODOLOGY

Using the theoretical framework, both authors separately developed a description of the evidence in microteaching of the teachers’ content knowledge, pedagogical content knowledge, pedagogical skill, and reflective practice. Description of the subsequent lesson was developed similarly but was also scrutinized in light of the feedback and self-reflection from the previous lesson. This facilitated an exploration of the enactment of their reflections and instructor feedback. Essentially, did they make changes to a later lesson given the experiences in the previous lesson? This allowed for a characterization of each teacher’s reflective practice to begin to emerge. The authors then developed a single case study of each teacher through repeated discussions of their individual descriptions and impressions. The analysis specifically included incidences of content errors, the teacher’s general comfort level with certain topics, evidence of consideration for learners, evidence of growth in a subsequent lesson, group discussion and their self-reflection.

Participants

The preservice science and mathematics teachers, Oscar, Yvonne, and Erica were selected because they were representative of a spectrum of content knowledge determined by the mathematics and science courses in their undergraduate degree programs, self-report, and instructor observations made during science and mathematics content activities embedded within the methods class. These activities will be described in greater detail in the analysis section. Yvonne, a mathematics preservice teacher, entered the program exceptionally confident about her content knowledge. Although she did not have experiences in classroom settings, she had tutored several family members in middle grades mathematics and was familiar, as a parent, with secondary mathematics curricula. At the time of the methods course she was dedicated, full time, as a stay at home mother. Her previous positions were each in technical fields that involved mathematics including statistical methods and accounting procedures.

The other mathematics preservice teacher, Erica, had low self-efficacy as evidenced anecdotally through her verbalizations about her discomfort with her subject matter knowledge. She was also pursuing certification as a second career and had experience in previous positions with accounting. Although her content knowledge was not as developed as the other preservice teacher, she was employed as a substitute teacher and teacher's aide. Little of her reflection centered on her experiences in the classroom, however.

The third participating teacher, Oscar, was enrolled in the same program as Erica and Yvonne but by contrast had a more sophisticated understanding of both his subject matter and pedagogy. He was the youngest of the three participants and had graduated from university two years prior to the study. Within his undergraduate program he had the opportunity to work as a research assistant in a research lab and hoped to be able to bring more non-traditional, reforms-based content (i.e. nature of science and scientific inquiry) into his classroom.

Analysis

Several mathematics and science content activities were embedded within the course as models of lesson strategies. The preservice teachers reactions to these lessons further illustrated the differences in content knowledge and content-specific self-efficacy of each of them. One mathematics lesson, in particular, demonstrated the stark contrast between Yvonne and Erica. This lesson was designed to allow participants to visualize operations with fractions using tiles without depending exclusively on the algorithm for a solution. While Yvonne worked through each of the problems successfully and with enthusiasm, Erica became increasingly frustrated and struggled with the visualization of the multiplication and division of fractions. After the activity, Erica became very emotional and described her frustration with "material she thought she understood". This activity took place early in the semester and was the first of many instances when she voiced concerns with her content knowledge.

The teachers' first encounter with lesson planning and teaching was content neutral. During an early class session, they were asked to write a lesson plan on the topic "Tying a shoe", and then teach it to their peers. The instructors provided a model of a shoe and laces. The difference in their knowledge of learners and pedagogy began to emerge during this activity. Yvonne used a model of a shoe to show students five times how to tie a shoe, and then she asked them to repeat the process, never showing students the rationale for the lesson. In contrast, both Oscar and Erica introduced the activity by showing students why it is important to learn how to tie a shoe. Oscar entered the room with his shoes untied tripping to initiate the discussion of the importance of having shoes tied. Erica simply asked what would happen if their shoes were untied to elicit students ideas. This initial activity illustrated that they fall on a spectrum of knowledge about learners and pedagogy. The following paragraphs provide more details about each teacher.

Yvonne

Yvonne's first lesson exemplified her confidence in her mathematical knowledge in contrast with the second mathematics teacher, Erica. The lesson was written for a second year algebra class and focused on solving systems of equations graphically. The content of the lesson was both accurate and appropriate for the secondary classroom she developed the instruction for. Understandably, the pedagogical sophistication of its implementation was lacking and while this is not concerning particularly given that this was the first teaching experience for Yvonne, her reflection on the experience did not suggest a consciousness of the growth needed for effective teaching. More typical teaching concerns such as the appropriate use of wait time before accepting student responses to teacher's questions and having limited movement around the classroom or interactions with students were evident. More subtle, though equally common, instances of lacking pedagogical content knowledge were also an issue. For example, although it is possible (and pedagogically acceptable) for a student to graph a line *without* first putting it in the $y=mx + b$ format, Yvonne required that students make this change prior to graphing. She was confident with this material; however, she was not flexible with the graphing of all forms of the equations. Consequently, she was unable to teach this content in a variety of ways.

Her reflection on the lesson itself, after viewing the video of her experience, essentially lacked any reflection at all. In particular, she noted one strength of her teaching episode, “I felt prepared”; and a few weaknesses, “assessing students’ understanding, missed teaching opportunities, and facing the board when writing.” Nevertheless, she did not use this information to describe what changes she would make if she could teach it again, which was a part of the reflection assignment. The only substantive statement, “I felt like the time got away from me, and I was not able to give a concise summary” did acknowledge the lack of closure to the lesson as pointed out to her by the instructors during the debriefing session after the lesson, as well as on their written feedback.

The following lesson did include this much-needed component of lesson planning and implementation. However, this was the only aspect of planning and instruction that improved between the first and second lesson. In her reflection to the second teaching episode she outlined the same strength, “I felt really good about the topic”, and weaknesses, “assessing students’ understanding, missed some learning (maybe teaching) opportunities, and still facing the board, but less this time.” This further illustrated her confidence in her mathematical knowledge, but also the lack of understanding of the importance of revisiting ones own understanding in order to become effective teacher.

Erica

Erica consistently voiced concerns about her content knowledge and was apprehensive about her preparation for mathematics teaching from this perspective. In contrast, her experiences as a substitute teacher and teacher’s aide gave her insight into the realities of teaching and the needs of students that the other preservice teachers did not have. The content of her lessons included in the analysis was accurate and appropriate for the middle grades mathematics classroom she was preparing for. Her first lesson was an introduction to the use of a protractor. The introduction to the lesson, in which students created paper airplanes, as well as her extensive use of questioning evidenced Erica’s knowledge of students. Within her reflection on the lesson, her acknowledgment of her own strengths and weaknesses were consistent with the instructors’ perceptions including those that were not explicitly shared with her during the debrief of the lesson’s implementation. Even within the pedagogical concerns she identified there was a consistent and overarching concern with her subject matter knowledge.

> *I used a lot of “ums” and “so” and I need to make a conscious effort not to do that in class. It begins to take away from the lesson and possibly give an impression of not being confidant or knowing the material.*

The lesson that followed was intended to provoke discussion of how mathematics is used as a selling tool within advertisements. Although this lesson did not go as smoothly as Erica intended, there were distinct and noticeable improvements made over her first lesson. For example, her use of questioning in both lessons was extensive but there were several instances in the first teaching session in which she did not wait before providing an answer or moving on to another student. This lack of wait time was a concern and was discussed during the debriefing session that followed. Her subsequent lesson showed observable improvements in this regard and she pointed out in her reflection that she had “good time left between questions from the teachers to students to allow them to respond to questions asked". A linear relationship between the two cannot be argued here due to the limited scope of the data analyzed, however, growth between teaching episodes was evident. Furthermore, Erica made explicit references within her reflection on her first teaching experience regarding both positive and negative teaching moments and pedagogical choices that were then corrected in the next lesson. Although her mathematical knowledge was less developed than Yvonne, she was considerably more reflective about the instructional content and demonstrated more significant growth between lessons.

Oscar

In contrast with the other two participants, Oscar had both a sophisticated understanding of his content relative to the secondary biology curriculum, and also demonstrated pedagogical thoughtfulness that is generally uncharacteristic of preservice teachers. Analysis of his teaching and lesson planning before and after reflection demonstrated the nature and influence of Oscar's reflective practice. The first lesson he implemented for the methods course focused on mutations in DNA sequences. The content of the lesson was accurate and appropriate for the intended audience and there were also instances within the lesson design that demonstrated Oscar's awareness of and attention to student misconceptions and beliefs. For example, he began the lesson with a picture of cartoon characters that the students were familiar with and used them as a platform to draw out their conceptions of the nature and implications of mutations within individuals. Although this was Oscar's first teaching experience, evidence of developing pedagogical content knowledge also emerged within the analysis of his teaching and lesson planning. Within this first lesson, he effectively developed and used analogies to present unfamiliar ideas.

Oscar did have some difficulties, however, with effectively working through the misconceptions he was able to draw out. Within his reflection on his lesson he discussed in detail his own frustrations with his inability to effectively describe the phenomena he intended to. Oscar's reflection on the first lesson went beyond the specific focus points of the post instruction debrief and he included concerns about the experience that were not noted by either instructor or his peers.

> *When we were talking about mutations that could be beneficial for a lion we named a few and I explained how these traits are passed down and how lions would become faster and faster. Then later in the discussion Yvonne asked about traits and heredity in terms of her brother and I then said that those aren't passed on. So I contradicted myself and may have confused the students and created a misconception that traits are not passed on from generation to generation.*

Instances such as this one illustrate two things about Oscar when compared to the other two participants. The first is that Oscar's weaknesses lay, understandably, within his knowledge of learners. A weakness most notably improved through experience, which he did not yet have. The second is that he was much more reflective about his practice than Yvonne with an equally sophisticated understanding of content. More importantly, the impact of this reflection was observable in the following teaching experience.

Oscar focused the second lesson on meiosis and specifically on providing students with an experience to help them to understand and remember at which stage of meiosis crossing over occurs. Although the lesson had some logistical concerns, there was a distinct and noticeable improvement in his attempts to use questioning to draw out misconceptions and to reinforce understanding. Additionally, while the previous lesson had a teacher-centered conclusion in which Oscar essentially restated the definition of a mutation and reiterated diseases attributable to them, closure of the second lesson was student centered and consisted of Oscar posing questions to the students and using their responses as a review of the material just discussed.

Conclusions and Implications

The three profiles just described are representative of a continuum of teacher knowledge and reflection and are illustrated in the figure below.

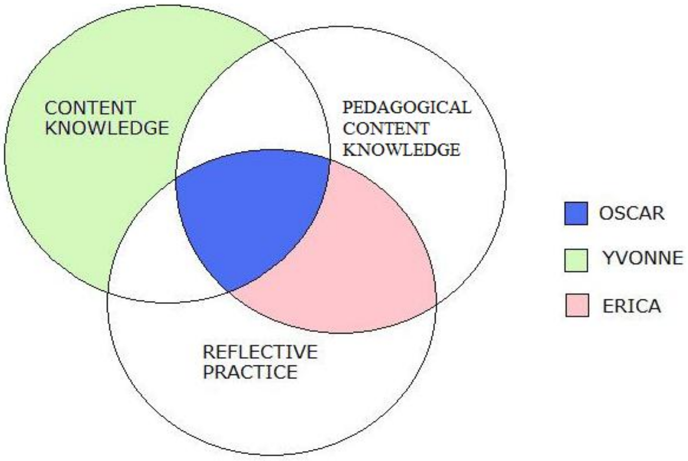

Figure 1: Teachers' profiles

Yvonne, represented a typical preservice teacher. She had sufficient content knowledge, but had no knowledge of pedagogy and students. Quite the opposite was Erica, a mathematics preservice teacher who consistently expressed concern regarding her content knowledge, but showed knowledge of pedagogy and students that is not expected of someone just beginning a certification program. Lastly, Oscar, a science preservice teacher, demonstrated sufficient content knowledge as well as knowledge of pedagogy and students. The differences among these three preservice teachers were obvious after their first teaching session. However, in this study we were interested to see if the difference in content knowledge affects how preservice teachers reflect on their microteaching experience, and how this reflection influences future practice. Although the assertions that can be made here are limited, given the scope, the case studies developed ultimately suggest that content knowledge is not a determining factor in the development of pedagogical knowledge. The critical factor in the transition between content knowledge and the development of pedagogical content knowledge is reflection.

While Schön (1983) emphasized the distinctions between reflection-on-practice and reflection-in-practice, and both are of critical importance, this study limited itself to preservice teachers' reflection *on* their practice. Even among experienced inservice teachers influencing changes of reflection in action is problematic (Derry, Wilsman, & Hackbarth, 2007). This study, furthermore, does not aim to describe a means for facilitating change in teacher practice but is instead a characterization of the relationship between content knowledge, PCK development, and reflection.

The implications for this study include changes in the way feedback is provided to preservice teachers such as the participants in this case. Given the concern with the development of pedagogical content knowledge, incorporating content specific prompts intended to elicit their thoughts about what subject content *is* specific to teaching should be included when possible. Also, preservice teachers should be asked to explain how PCK-related feedback impacted subsequent lessons or lesson planning in addition to particular aspects of their common content knowledge and pedagogy.

The development of PCK is not automatic and mathematics and science teacher educators routinely provide feedback to encourage growth in both pedagogical skill and, when possible, content knowledge. This study illuminates current understanding of the potential relationship between content knowledge and the development of pedagogical content knowledge and the role of reflection as a mediator between the two.

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INTEGRATING EDUCATION FOR SUSTAINABILITY INTO PRE-SERVICE PRIMARY TEACHER EDUCATION: FORGING CONNECTIONS IN SCIENCE AND TECHNOLOGY

Frances Quinn
University of New England
fquinn@une.edu.au

Mike Littledyke
University of New England
mlittled@une.edu.au

Neil Taylor
University of New England
ntaylor6@une.edu.au

Carol Davies
University of New England
cdavie24@une.edu.au

ABSTRACT

Recent studies have highlighted the need for better integration of Education for Sustainability (EfS) into pre-service teacher education in Australian universities. This case study explores some of the issues surrounding this imperative in one institution, with particular emphasis on the Science and Technology Key Learning Area in Primary teacher education. It found that key concepts within ecological sustainability were thoroughly covered in the Science and Technology units, that, although some efforts were made to link these to broader issues of political and social sustainability, this was constrained by a number of systemic barriers, and that issues of economic sustainability were scarcely visible across the degree program. The study highlighted the difficulties of addressing EfS in a holistic way within tightly circumscribed science and technology units, and that improved, explicit communication structures were essential to facilitate conceptual links between EfS concepts within the Science and technology area, and between Science and Technology and other Key learning Areas within Primary Education awards.

INTRODUCTION

The need for effective Education for Sustainability (EfS) in school-based education is now compelling, as the planet faces significant environmental challenges of which global warming is the most high profile. EfS should encourage students to become more socially critical and begin questioning their own and societal behaviors with respect to environmental impact. Accordingly, EfS is commonly perceived as a cross-disciplinary endeavour: an underlying perspective or referent that should inform and permeate all aspects of students' school experience. Australia, a country beset by environmental problems associated with human activity such as land clearing and a major contributor to carbon dioxide emissions, has taken these challenges on board to some extent. Strong EfS policy statements have been produced at both federal and state levels (Commonwealth of Australia DEH, 2005; Australian Government, Department of Environment, Heritage and the Arts, 2009), along with the Australian Sustainable Schools (AuSSI) initiative and many excellent examples of whole-school, action-oriented initiatives connecting community, curriculum and the management of school resources and grounds (Australian Government, Department of Environment, Heritage and the Arts, 2005). However, the uptake of these policies and initiatives is very patchy, and strongly dependent on individual champions of the cause in schools. In addition, many shortcomings in the teaching of EfS reviewed by Tilbury, Coleman and Garlick (2005) persist at both the primary and secondary levels.

Some authors (e.g. Cross, 1998; Taylor, Nathan & Coll, 2003) reported that both primary and secondary teachers, even those with a particular interest in the environment and sustainability issues, had limited understanding of the concept of sustainable development or sustainability goals. Furthermore, Walker (1995) argued that teachers considered that EfS requires specialist knowledge and this perception inhibited their efforts in this area. As an example, teachers may lack knowledge of EfS pedagogy including the skills of integrated planning. Certainly there are many studies indicating that teachers do not hold the knowledge and understanding that is deemed necessary for implementing EfS. These include reports that teachers may lack understanding of the fundamental ideas and practical procedures underpinning EfS (Robertson & Krugly-Smolska, 1997; Skamp & Bergmann, 2001; Summers, Corney & Childs, 2003; Taylor, Nathan & Coll, 2003; Kennelly, Taylor & Jenkins, 2008; Skamp, 2009). There are also reports that teachers may lack understanding of environmental concepts (Summers et al., 2000; Khalid, 2001; Cutter-Mackenzie & Smith, 2003; Flogaitis, 2003; Summers, Corney & Childs, 2004, 2005; Parlo & Butler, 2007; Skamp, 2009). As an example, Skamp (2009: 103) concluded that:

> Content knowledge is a prerequisite to pedagogical content knowledge. Teachers will not engage students in a wide variety of environmental … activities if they are unaware of the environmental knowledge associated with the cognitive outcomes from those activities… Awareness of general and abstract environmental knowledge may not be sufficient…Explicit professional development workshops focusing, in part, on specific content knowledge … might address this issue.

A consequence of this limited understanding of EfS is that teachers lack confidence in their ability to question and change prevailing conditions in their schools. Jenkins (1999/2000) reported feelings of disillusionment and disempowerment amongst pre-service teachers, because the responsibility of teaching EfS was too great and they believed they could not make a difference. Teachers have also expressed a strong need for the support of their principal and colleagues for their EfS efforts (Kennelly, Taylor & Jenkins, 2008). A lack of confidence can only be expected, in an educational endeavour, which has been described as ‘transformative’ and which in many practical ways challenges everyday expectations and routines of school.

The inference is that the pedagogy of EfS and the social and ecological understanding deemed necessary may have been missing from teacher preparation, or where they have been included, they may not been offered in such a way as to allow, or to motivate teachers to make connections between human practices, ecological understanding and their relevance to teachers’ everyday professional work. This is very unfortunate, as, according to Said, Ahmadun, Paim and Masud (2003), teachers are potentially instrumental factors in the formation of students’ attitudes about the environment. Furthermore, research by Miles, Harrison and Cutter-Mackenzie (2006) with pre-service teachers in Australia, indicated that in general these teachers were keen to draw on EfS in their future teaching. However, this research also confirmed that many of these teachers felt their levels of preparedness and confidence were low and their knowledge inadequate.

Many of these issues suggest that teachers, both primary and secondary, are inadequately prepared in the area of EfS, and certainly based upon their findings in the Australian context, Miles et al. (2006: 57) concluded that:

> Despite national and international policy rhetoric about the importance of pre-service teacher preparation in environmental education … there are still inadequate levels of environmental education provision at the teacher education level and that pre-service teachers’ preparedness for teaching environmental education is overwhelmingly low.

Other authors have made similar claims about EfS in teacher education in Australia. According to Tilbury, Coleman and Garlick (2005), there has been a dearth of EfS in teacher education programmes and this has resulted in a lack of competence amongst teachers to effectively teach EfS in schools. Similarly, Cutter-Mackenzie and Smith (2003) argue that it is the lack of pre-service and in-service teacher training in EfS that poses one major barrier preventing or limiting the effective implementation of EfS in primary schools. These and other authors (e.g., Ferreira, Ryan and Tilbury (2007), Fien and Tilbury (1996), Tilbury, Coleman and Garlick (2005) have signposted the need to integrate education for sustainability (EfS) into pre-service teacher education programs.

Several examples of integrating EfS into teacher training courses are emerging. Recent projects emanating from The Australian Research Institute in Education for Sustainability (ARIES) have strongly promoted and facilitated integration of EfS into teacher training programs at several Australian universities. One of these projects was the catalyst for the research reported here. Paige, Lloyd and Chartres (2008) have reported a transdisciplinary approach to integrating EfS into primary teacher education where science, mathematics and ecologically-related aspects of society and environment and are taught in an integrated way based on clearly articulated rationale of educating for ecological sustainability. The challenges and opportunities of online teaching of environmental education pre-service teacher education have been discussed by Whitehouse (2008).

The Australian draft National Curriculum (Australian Curriculum Assessment and Reporting Authority (ACARA), 2010) has potential for incorporating EfS more comprehensively than some existing State curricula, with “Commitment to Living Sustainably” as one of three cross curricular themes which is explicitly mapped throughout the curriculum strands. Sustainability is also referred to in aspects of History, for example, referring to ‘concern for the environment’, while science has a number of aspects that refer to the applications of science to society and the world, including, for example, ‘an ability to solve problems and make informed evidence-based decisions about current and future applications of science, while taking into account moral, ethical and social implications’.

The research reported here examines issues related to integrating EfS within the Primary Education awards currently being offered at one of Australia’s oldest and well-known teacher education institutions. The study focuses on the Science and Technology Key Learning Area in primary teacher education, and is embedded within an action research framework. It is one of a sequence of iterative cycles of action and reflection that has informed the integration of EfS in the Science and Technology key learning area of pre-service primary teacher education at our institution. It builds upon and is informed by preceding studies relating to our local teaching and learning context (Taylor, Kennelly, Jenkins, & Callingham, 2006; Kennelly & Taylor, 2007). It also draws upon subsequent broader, collaborative, cross-curricular activities such as editing a book specifically targeted at primary school educators (Littledyke, Taylor, & Eames, 2009) and participation in a cross-institutional project aimed at mainstreaming EfS into pre-service teacher education (Littledyke et al., 2009). By reflecting and acting upon our local context as simultaneously investigators and participants within an action research framework, we aim to enhance the ability of our graduates to integrate EfS into the Science and Technology key learning area at primary schools.

RESEARCH CONTEXT

This study, which is part of a broader, cross-institutional project, focuses on six units that are offered in various primary education pathways at a rural Australian university with a long history in teacher education.

The six units at the focus of this study contribute to the science component of awards, which are structured along traditional disciplinary boundaries reflecting the key learning areas in school syllabus documents. Two of the units are core 2nd year units for students studying a Bachelor of Education (Primary): one of these is face-to-face and the other unit is by distance, with a five-day face-to-face intensive school on campus. A further unit is a core 4th year unit called "Primary Environmental Science for Sustainability". This unit has a dual focus: to build on the scientific content knowledge of the 2nd year science and technology units, and to better integrate EfS into the primary teaching degree. Its development was founded on strong theoretical underpinnings and from a philosophy consistent with holistic, integrated practice (see Kennelly & Taylor, 2007), with a thematic approach emphasising action-competence and experiential learning, including field trips ranging from a sewerage treatment plant to a World Heritage National Park. The remaining three units are electives with much smaller enrolments, taken by students taking other degree pathways, for example, combined General Studies/Teaching degrees. All of these units are the responsibility of three unit co-coordinators who were participants in this research.

The national context at the time of the study included imminent release of a new National Curriculum (now released in draft form), and the recent adoption of National Assessment in Literacy and Numeracy, results of which may be linked to school funding. A national joint initiative called 'Primary Connections', between the Federal department responsible for education and the Australian Academy of Science, is developing and disseminating high quality curriculum resources explicitly linking science with literacy outcomes.

METHODS AND DATA COLLECTION PROCEDURES

The study was conducted using a mixed-methods approach. Data collection for the broader project comprised two online surveys and a semi-structured interview with key teaching staff across the whole School of Education, including the Science and Technology team whose responses form the basis of this study.

In the first online survey, the concept of EfS was explicitly articulated according to the four themes of ecological, social, economic and political sustainability, following Commonwealth of Australia DEH (2005). These survey items asked participants to indicate whether their units explicitly addressed key concepts identified by Commonwealth of Australia DEH (2005), and shown in Table 1, within each of the four sustainability themes.

Table 15: Key concepts within the four dimensions of sustainability (source: Commonwealth of Australia 2005, p. 17)

Ecological sustainability	Social sustainability	Economic sustainability	Political sustainability
Biodiversity	basic human needs	Cost-benefit analysis	citizenship
Habitat	cultural diversity	Economic development	democracy
Carrying capacity	cultural heritage	Eco-efficiency	decision-making
Conservation	human rights	Life-cycle analysis	tolerance
Ecological footprint	intergenerational equity	Natural capital	power
Ecology	participation	Natural resource accounting	respect
Ecospace	peace	Steady-state economy	conflict resolution
Ecosystems	risk management	Sustainable consumption	
Interspecies equity	social justice	Sustainable production	
Natural cycles and systems		Triple-bottom line	

In order to map the integration of EfS concepts in the formal curricula of the units at a reasonably fine scale, this survey asked participants to indicate whether or not each of the concepts shown in Table 1 were explicitly addressed within the following aspects of the units: title, synopsis, lecture topics, readings, tutorial/workshop activities, web resources, summative assessments and/or learning outcomes.

The second online survey focussed on unit coordinators' perceptions of sustainability and EfS, and the perceived barriers and opportunities to incorporate EfS into their units and more broadly into the School of Education. Participants provided responses to survey items, which also included open-ended questions about their perceptions of EfS and their teaching practices. Likert scale questions relating to perceived importance of aspects of EfS were rated on a 5-point scale from Very Low to Very High, while questions relating to the extent of EfS inclusion were rated from Very Little to Very High. Surveys were administered using the SurveyMonkey software and filled in individually without consultation with other team members.

Interviews probed more deeply into individuals' perceptions of EfS, with particular emphasis on barriers, opportunities and required actions. Interviews were structured to some extent by questions focusing on themes of interest, followed standard protocols relating to ethics and confidentiality, and were audio taped.

In order to summarise the profile of EfS across the units, a profile index was calculated for each of the dimensions of ecological, social, economic and political sustainability. This is the total number of times that the individual concepts within each dimension occurred in the different aspects of the six units. Responses from the science and technology staff were collated to provide a picture of the individual and collective perspectives underlying the teaching in the Science and Technology units. Illustrative quotations are taken from the survey responses to provide richer account of the views of the staff.

RESULTS

PROFILE OF EFS WITHIN SCIENCE AND TECHNOLOGY UNITS

The profile of the four dimensions of EfS across the units, as indicated by the profile index, is shown in Figure 1.

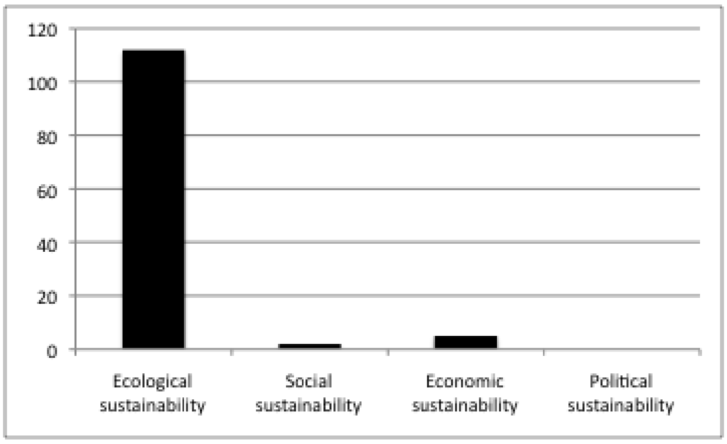

Figure 4: Profile of the four dimensions of Education for Sustainability across six Science and Technology-related units.

As shown in Figure 1, while ecological sustainability was covered extensively within Science and Technology units taken by pre-service primary education students, the other three dimensions of sustainability were mainly invisible. None of the concepts central to political sustainability were reported as being explicitly addressed in any of the units. Within the dimension of social sustainability, only the concept of risk management was addressed in part of one of the units. Within economic sustainability, only the concepts of sustainable consumption and production were addressed.

The more detailed picture of the coverage of concepts within ecological sustainability across the six units, using the same indexing procedure as above, is shown in Figure 2.

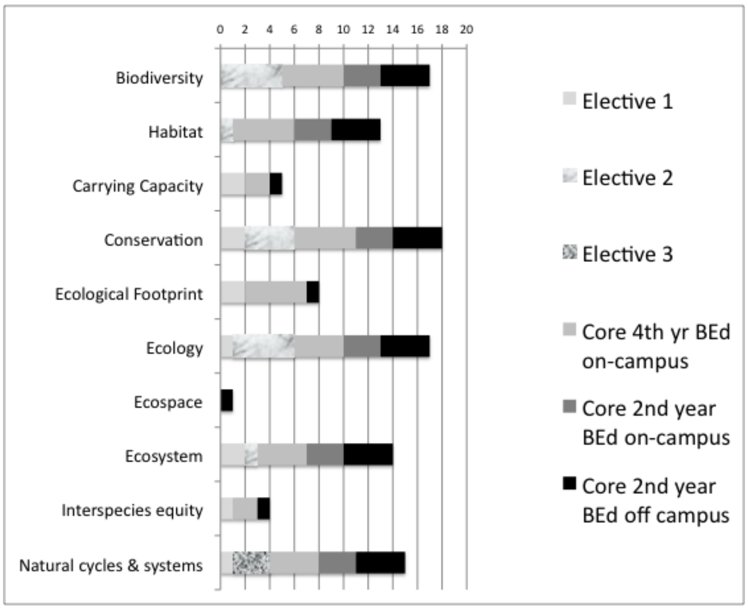

Figure 5: Concepts of ecological sustainability addressed in Science and technology units taken by primary education students

As indicated by Figure 2, the core units explicitly cover most of the key concepts, with the exception of the idea of ecospace, which is addressed only in one of the core units. Overall, the concepts of conservation, biodiversity, ecology, natural cycles and systems and ecology were respectively the best represented. These concepts are also the most narrowly 'scientific', in the sense that they do not subsume to any significant extent concepts of equity and resource use that are such important components of the ideas of ecospace, interspecies equity, carrying capacity and ecological footprint, which were much less represented.

PERSPECTIVES OF SCIENCE AND TECHNOLOGY TEACHING STAFF

Many common views were apparent among the self-reported perspectives of the four staff members associated with the Science and Technology unit. All rated the importance of EfS generally as Very High.

- Teachers must be well prepared to teach EfS because of the seriousness of global problems of sustainability
- If they [the pre-service teachers] don't go out there prepared to take action and prepared to sort of think critically about what they are hearing, or what they use, or what they doing, then you know, it's not going to get any better.

All rated the importance of EfS in the Science and Technology teaching area as High or Very High:

- Many EfS concepts link to science concepts - also I feel that good EfS should be underpinned by a good understanding of science concepts.

Similarly, all the staff rated tacit matters such as their own values, attitudes and practices in EfS as High or Very High.

- It is important for me as a lecturer to covey the types of values etc that I hope my students will adopt
- I think you've got to provide a model of good practice yourself, in how you talk about the environment, in how you deal with the environment… if you're actually behaving in a way that's contrary to what you're teaching then I don't think that's good.

All the participants rated as Very High the importance of EfS being addressed systematically across curriculum areas of teacher education programs in the School of Education. A number of barriers to this imperative, spanning a range of several externally imposed constraints and internal practices, were also highlighted.

Arguably one of the most intractable externally imposed perceived barriers related to the narrowly circumscribed requirements mandated by one of the professional accreditation organisations. The narrow and specific unit outcomes adopted in compliance with accreditation requirements flowed on, via the logic of 'constructive alignment' (Biggs, 1999) to many other aspects of the units including the activities and assessments. For example, in part as a consequence of accreditation processes, the 'Primary Environmental Science for Sustainability' unit originally designed to provide a rich experiential and action-oriented learning environment was slightly reoriented via assessment changes in a way that runs theoretically counter to these ideals of EfS. Comments relating to this particular barrier to integrating EfS into the Science and Technology stream included:

- Demands of DET [Department of Education and Training] and NSWIT [New South Wales Institute of Teachers] emphasise state standards and curriculum, which has low priority for EfS

- The need to cover a range of science concepts in more breadth/depth, and NSWIT requirements that closely define the outcomes that I can address in one science/sustainability unit

- Professional accreditation constraints and demands coupled with narrowly circumscribed disciplinary areas in the course structures

Other issues of concern raised by some of the Science and Technology staff included a perceived lack of scientific background among the students, and perceived irrelevance of EfS to staff and students:

- Quite a number of those students were really interested in sustainability but had not the slightest clue about how to go about teaching the fundamentals from an environmental perspective or from a scientific perspective, they simply had not the scientific ground to do so.

- Perceived irrelevance (by staff and students) of EfS to individual teaching areas.

An internal issue raised included a lack of integration and communication between disciplinary areas in the primary awards:

- Silo mentality of tutors in units and teaching areas creating major barrier to integration

- EFS is really, in my view of it, it's a holistic, cross-cultural, multi- perspective type of thing and we can teach it from a science perspective … but the breaking down of a curriculum into these little units for us and for the school kids is one barrier, the other is that we need more integration and communication of what is in the individual units.

Discussions of the barriers to integration of EfS also highlighted concomitant possibilities to enhance integration. The major mechanism to further enable EfS raised was improved communication:

- I would like to see much more vertical integration and communication of what is in the different units in the awards.

- Cross-discipline team discussions and plans for sequencing and incorporating aspects of EfS semester by semester, year by year across courses

In general, the second survey and follow-up interviews indicated that our team and associated staff were highly committed to principles of sustainability, both in our personal lives and professional roles, and within the science units attended to tacit issues and positive role modelling in teaching practices. We shared strong concerns about the impact of accreditation processes on integrating EfS into and beyond the Science and Technology discipline, and saw improved communication and integration between staff across different disciplinary areas as a necessary and crucial enabler of better integration of EfS.

DISCUSSION

In discussing these results, the first point to be made is that we view the reflective processes involved in participating in the study itself, as an extremely useful professional experience, which has inspired our continual involvement in this endeavour and prompted us to consider ways of refining our praxis. This collaborative process is consistent both with principles of action research models (Kemmis and McTaggert 2005) and the broader ideals of sustainability.

It is apparent from the results that even though interconnectedness is theoretically more tractable in primary education systems (Littledyke, Taylor & Eames 2009), and despite committed key staff working from a holistic philosophy over several years, integration of EfS into the Science and technology strand of primary teacher education is constrained in several ways that are consistent with previously documented problems in this area (e.g., Tilbury *et al*., 2005).

A reflection of these constraints is that, of the four recognised pillars of sustainability, we have really only dealt with ecological sustainability to any significant extent in these units. Although this is perhaps entirely appropriate for the Science and Technology disciplinary area, given the importance of making connections between aspects of ecological sustainability and other pillars of sustainability this could be viewed as a limitation. Despite the inclusion of an assessed activity designed for the students to make links between concepts across the four pillars of sustainability (based on an activity described by UNESCO (2006)), it is unlikely that the graduating students had had the opportunity to develop strong relational understandings within and between these broad themes.

This is, of course an issue because EfS is about connections: connections within and between trans-disciplinary sustainability issues and disciplinary content, connections between the different pillars of sustainability, as well as connections between schools and community, between knowledge and action, between people and place and between humans and nature. Of course, education more broadly is about connections, with connections between different forms of knowledge essential for meaningful, relational understanding. But students cannot make these connections all at once, because of well-recognised limitations to working memory (Demetriou, Christou, Spanoudis, & Platsidou, 2002) and because 'limitations to awareness' (Marton & Booth 1997) mean that students cannot be aware of all aspects of a phenomenon simultaneously. In the words of Paige et al. (2008) the disciplinary must precede the transdisciplinary. Which connections should be highlighted or take precedence by us as teacher educators and educators for the environment? Which connections are most relevant and beneficial for the pre-service teachers, who, as we know from several studies, avoid teaching science and technology because of a lack of knowledge and confidence about basic science concepts?

The connection between science and literacy established by the ‘Primary Connections’ project (Australian Government and Australian Academy of Science, 2010) is one direction that has already been established, because of the value of these resources and the pragmatic responses of teachers both lacking confidence in science and operating within a context of high stakes literacy and numeracy assessments. The existing focus on ecological sustainability in the degree programs clearly reflects the importance we have placed on the connections between the content knowledge in the units and the concepts specified in existing science and technology syllabus documentation. This strong emphasis should go some way to addressing ‘ecological illiteracy’ posed as a problem by Cutter Mackenzie & Smith (2003).

These connections are also directly relevant to what appears to be in the forefront of students’ awareness in the science and technology learning context (Marton & Booth 1997), namely, concerns that they have the appropriate conceptual understanding to facilitate primary students’ learning of scientific concepts and skills specified in the primary syllabus. Given the crucial importance of perceived relevance to the learning of tertiary students, this is an important consideration. Although environmental and sustainability concerns are also important for many of the students, the ‘limitations to awareness’ postulated by Marton and Booth (1997) foreground the more immediate, syllabus-mandated issues, leaving more relational, holistic issues related to sustainability more to the background. Yet in our view, it is equally if not more important and relevant for our students to understand the broader sustainability connections for themselves, and to help school children to make these connections.

While incorporating broad sustainability outcomes in tightly mandated and circumscribed professional courses is difficult to deal with, some of these problems can be ameliorated by better communication between teaching ‘silos’ and integration of EfS themes across disciplinary boundaries. Within the science and technology units, better integration of sustainability requires deliberate, sensitive and selective emphasis of broader, complex webs of sustainability knowledge and values with the more specific concepts and ideas, which are directly related to syllabus and accreditation imperatives.

Clearly, this is not enough for students to make the connections between the ecological, social, economic and political dimensions that we need them to make for a sustainable future. Bottom-up endeavours by committed educators for the environment can certainly enhance EfS within teacher education programs. What is needed, though, for these endeavours to be perceived as more directly relevant to both pre-service and in-service teachers and their accreditation agencies is a curriculum that explicitly incorporates sustainability outcomes. The extent of the success of EfS in the Australian National Curriculum will undoubtedly be influenced by assessment priorities given to curriculum content compared to processes, values and attitudes, as teachers’ practice is influenced by such priorities. It will also be influenced by the specificity, detail and amount of guidance provided to teachers in actually incorporating this cross-curriculum perspective, as well as the extent to which teaching emphases are driven by pressures associated with national literacy and numeracy testing. The potential consequences are exemplified by the relatively poor development of Environmental Education as a cross-curricular theme in the English and Welsh National Curriculum associated with its low priority for assessment in comparison with the core subjects (Littledyke, 1997).

CONCLUSION

Our endeavours to educate pre-service primary teachers about science concepts, about sustainability, about Education for Sustainability and **for** sustainability have focused on ecological sustainability, with much less emphasis given to economic, social and political aspects. This reflects the tension inherent between integrative, holistic approach espoused by many researchers in EfS and the constraints of disciplinary boundaries. While acknowledging the limitations of this approach, we will continue with this emphasis because of its direct relevance to the Science and Technology Key Learning Area and because of its perceived relevance to pre-service teachers, many of whom need to develop proficiency and confidence in scientific pedagogical content knowledge. In order for us and for our students to forge deeper and wider connections to other aspects of sustainability, the study has also highlighted the need to implement proactive communication strategies between teaching staff specifically for this purpose. The study has also raised for us the importance of repeated deliberate and strategic foregrounding of sustainability themes and links in our teaching that include and transcend the concepts of ecological sustainability. In this way we hope to assist our pre-service teachers to genuinely connect to the new National Curriculum's "Commitment to Living Sustainably' and to facilitate this commitment in the next generation.

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GENDER DIFFERENCES IN AUSTRALIAN STUDENTS' RELATIONSHIPS WITH SCHOOL SCIENCE

Frances Quinn
University of New England
fquinn@une.edu.au

Terry Lyons
University of New England
tlyons3@une.edu.au

ABSTRACT

This paper explores issues of gender in Year 10 Australian students' experiences of science at school, their self-reported ability in science and their perceptions of science as a subject choice for senior secondary school. A sample of 3759 Year 10 students from across Australia responded to Likert-style questions related to these issues, with findings showing gender differences in perceptions of science, self-rated ability, and reasons for choosing not to study further science. Moreover, interesting contrasts were revealed in patterns of difference of self-rated ability for boys and girls across single-sex and co-educational schools.

Keywords: *Girls in science, boys in science, self-efficacy, gender differences*

INTRODUCTION

The interaction between gender and issues such as attitudes to science, self-efficacy, retention in science education and science subject choices has been a focus of educational research for many years. A review of the literature on science attitudes (Osborne, Simon, & Collins, 2003) suggests fairly unequivocally that although girls may be as competent as boys they continue to hold less positive attitudes to science, and continue to opt out of physical sciences in particular. This is also reflected in a more recent comprehensive review of girls in science (Brotman & Moore, 2008) . Similar findings continue to be documented in recent international studies. For example, Australian data from the Program for International Student Assessment (PISA) (Thomson & De Bortoli, 2008) showed statistically significant gender differences (predominantly in favour of males) for all but two of the indices reported. Boys reported higher self-efficacy in science than girls, and although there were no overall gender differences in scientific literacy, boys performed significantly better than girls in explaining phenomena scientifically, but significantly worse in identifying scientific issues. The Relevance of Science Education (ROSE) project reports (e.g., Schreiner & Sjøberg, 2007) did not include Australian data but found gender differences on many aspects of school students' attitudes to science.

From a different perspective, a recent meta-analysis of research studies has emphasised the similarities between boys and girls in performance and traits related to the ability to succeed in science (Hyde & Linn, 2009) and concludes that raising awareness of gender similarities would be more fruitful than 'cultural overemphasis' of gender differences. By contrast, Thompson & De Bortoli (2008) concluded their summary of gender differences in Australian school students with the comment that "perhaps gender needs to be reconsidered as an issue for Australian education".

Closely intertwined with issues of gender difference are conflicting views on the relative merits of single-sex and co-educational high school settings for boys and girls. Smithers and

Robinson (2006) suggest that single-sex schools have been viewed as a potential solution to gendered classroom roles of girls as the 'secretaries' and boys engaging with the equipment, and ultimately to the underrepresentation of women in science. Single-sex schools have also been seen as advantageous for self-efficacy in subjects such as science, however the evidence relating to this issue is mixed (Schoon, Ross, & Martin, 2007). Some research shows advantages of single-sex schooling, particularly for girls (Hoffman, 2002; Warrington & Younger, 2001).

Other studies question the value of sex-segregated schools. Smithers and Robinson (2006) found little advantage to students of either single-sex or co-educational schools, including no evidence that gender-related gaps in science subject choices were narrowed by single-sex schooling. Similarly, studies reviewed by Osborne et al. (2003) show that girls in single-sex schools were not more likely to elect to study physical sciences than girls in co-educational schools. Very little evidence supporting better educational outcomes from single-sex schools was found in a comprehensive analysis by Billger (2006). In fact, some claims have recently been made in the science media that co-educational settings are better for students overall and lead to improved grades, particularly for boys, which is partially attributed to better classroom environments (Tel Aviv University, 2008). A recent review (Chouinard, Vezeau, & Bouffard, 2008) has suggested that 'when students and school background factors are adequately controlled, there is no academic advantage of single-sex schools for girls' and that further research into these issues is warranted.

AIMS

Against this theoretical background, this paper reports findings from a study of Year 10 girls and boys (aged 15 to 16) from both single-sex and co-educational schools. The aims of this paper are to determine any gender differences in:

a) their intentions towards studying science in the following year (the first of two years of senior secondary school)
b) the reasons for their science subject choices for the following two years.
c) their perceptions of science as it is taught up to Year 10 and
d) their self-reported ability in science

METHODS

This study is part of a larger research project exploring students' decisions about taking senior science (Lyons & Quinn, 2010) and focuses on quantitative data from student responses to a subset of questionnaire items from the main project. A sample of 3759 Year 10 students from across Australia responded to an online survey. They were asked about their science subject choices for the following two years and responded to an array of Likert-style questions about their perceptions of science education and science careers, supplemented by some open-ended response questions.
The items that form the focus of this paper are shown in Table 1.

Table 1: Survey themes and associated items

Theme	Relevant items
• Reasons for not choosing science in senior secondary school	• I chose no science subjects because I am not good at science. • I chose no science subjects because science is more difficult than other subjects. • I chose no science subjects because I can't picture myself as a scientist.
• Liking of school science	• Test Of Science-Related Attitudes (TOSRA) Enjoyment scale (all items; available from Fraser (1981)) • I like school science better than most other school subjects. [This item taken from the Relevance of Science Education (ROSE) study (Schreiner & Sjøberg, 2007)]
• Self-efficacy	• How would you rate your own academic ability in science this year compared to others in your class?

In order to facilitate a concise visual representation of responses to the Likert-style items, some results are depicted in terms of means and standard errors. The mean responses to the TOSRA Scale were compared by ANOVA. However, although a large body of evidence endorses the robustness of parametric analysis of Likert-type responses (e.g. Glass, Peckham & Sanders, 1972; Jaccard & Wan, 1996; Neuman 1994; Zumbo & Zimmerman, 1993), including single Likert items in some cases (for discussion see Carifio & Perla 2007) we have restricted our analysis and reporting of potential differences between responses to single Likert items here to conservative use of non-parametric statistical techniques such as chi-squared contingency table tests.

Because of the large sample size and the number and types of statistical tests undertaken in the wider study, a conservative level of significance of $p \leq 0.001$ was adopted. In the case of chi-square tests, Cramer's V was used as a measure of effect size and interpreted according to Cohen's criteria (1988 cited in Gravetter & Wallnau, 2005 p. 475). For one degree of freedom, Cramer's V between 0.1 and 0.3 is interpreted as a small effect, between 0.3 and 0.5 a medium effect and greater than 0.5 a large effect. Adjusted Standardised Residuals (ASRs) were used to locate the sources of difference detected by statistically significant chi-square relationships. ASRs greater than +3.30 or less than -3.30 indicate significant differences (at 99.9% probability level) between observed and expected cell counts, while ASRs outside +/- 2.58 are suggestive of significant differences at 99% probability level.

RESULTS

SCIENCE SUBJECT CHOICES

There was no statistically significant difference between boys and girls in the frequency with which they chose no science at all for the following year. Gender differences were, however, evident in frequency of different subject choice categories [$\chi 2$ (3) = 227.9; $p<0.001$; Cramer's V = 0.30]. Girls chose physics (in combination with any other science) much less frequently than boys [ASR = +/-14.6]. Girls much more frequently chose biology without either chemistry or physics [ASR = +/- 9.9] and to a lesser extent, chemistry without physics [ASR = +/-4.2]. Some of these gender differences existed even among students who rated their science ability as "Much better than average" [$\chi 2$ (3) = 17.46; $p=0.001$; Cramer's V = 0.19]. Among these students, girls were still more likely than boys to take chemistry without physics [ASR +/- 3.5]. They still chose to take physics (in combination with any other sciences) less frequently than boys [ASR +/-4.0], but this gender gap was much less extreme than in the overall cohort. Amongst the students with the highest self-rated ability there was no statistically significant gender difference in the frequency of choosing biology or other science (without chemistry or physics), or choosing no science at all. There were no meaningful statistically significant differences between students from single-sex and co-educational schools in the frequencies of physics, chemistry or biology subject choices, for either girls or boys.

REASONS FOR CHOOSING OR NOT CHOOSING SCIENCE

There was no meaningful significant association detected between sex and reasons for choosing science in senior secondary school. By contrast, there were meaningful significant associations apparent between sex and three of the seven items relating to students' reasons for **not** choosing science. These results are shown in Figure 1.

As suggested by Figure 1, girls agreed significantly more frequently than boys with the statements "I chose no science subjects because I am not good at science" "I chose no science subjects because science is more difficult than other subjects" and "I chose no science because I can't picture myself as a scientist" [All items significant at $p<0.001$: $\chi 2$ (4): [a]= 36.12; Cramer's V = 0.20; [b] = 27.85; Cramer's V = 0.18; [c] = 20.00; Cramer's V = 0.15]. These differences, which all relate to the girls' perceptions of themselves, their ability and the difficulty of science rather than external issues related to careers, teachers or timetables, relate coherently to the girls' lower self-efficacy found in this study.

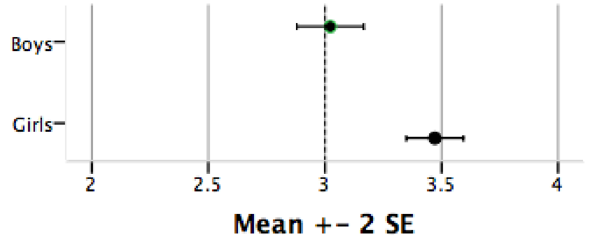
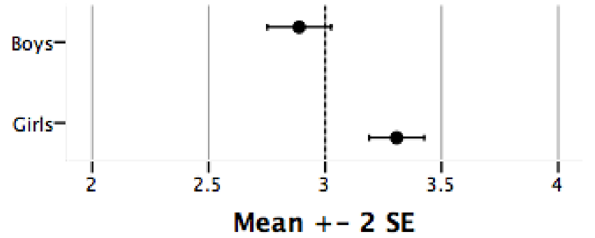
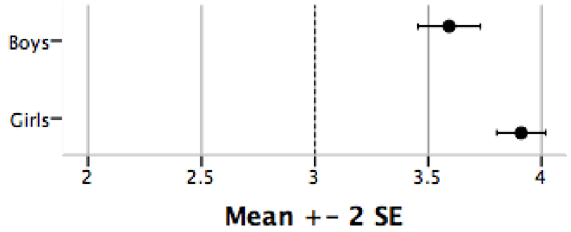
<table>
<tr><th>Item</th><th>Means and standard errors of item for boys and girls</th></tr>
<tr><td>I chose no science subjects because I am not good at science [a]</td><td>
</td></tr>
<tr><td>I chose no science subjects because science is more difficult than other subjects b</td><td>
</td></tr>
<tr><td>I chose no science subjects because I can't picture myself as a scientist c</td><td>
</td></tr>
</table>

Figure 1: Means and standard errors of responses of boys and girls to three items related to them choosing no science for the following year. [Response scale: 1 = Strongly disagree, 2 = Disagree, 3 = Unsure, 4 = Agree, 5 = Strongly agree]

LIKING OF SCHOOL SCIENCE

The TOSRA Enjoyment scale was reliable (α = 0.93) and comparison of scale means showed no meaningful significant difference between the responses of boys and girls. Although the mean response for boys was higher than that of the girls, [F(1,3755) = 10.156, p = 0.001], the effect size ($\eta p2$ = 0.003) was trivial.

The means and standard errors for student responses to the question "I like school science better than most other school subjects", broken down by sex, are shown in Figure 2. Mean responses below the mid-point indicate disagreement.

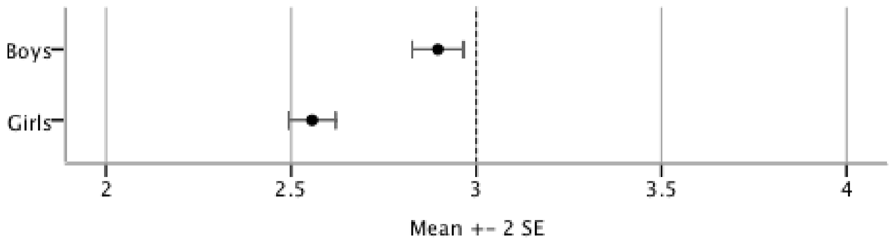


Figure 2: Means of responses to the item "I like school science better than most other school subjects" for boys and girls. [Response scale = 1 (disagree) through to 5 (agree)].

As shown in Figure 2, both boys and girls tended to slight disagreement with this item; on average, students did not like science more than other school subjects. Boys agreed with this item slightly more frequently than girls [$\chi 2$ (4) = 55.58; p<0.001; Cramer's V = 0.14]. For this item, there was no significant difference detected in responses from single-sex and co-educational schools, across the cohort as a whole.

Self-efficacy

The means and standard errors for students' self-rated science ability are shown in Figure 3.

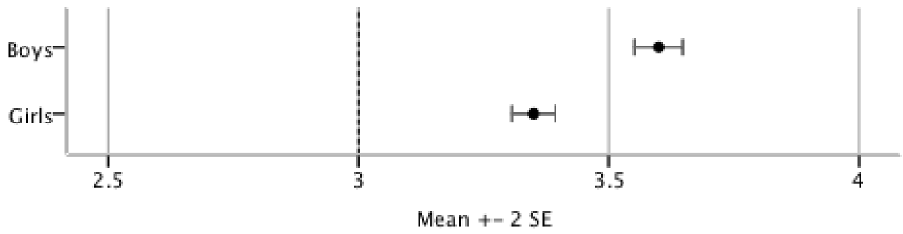


Figure 3: Means of responses to the item "How would you rate your own academic ability in science this year compared to others in your class?" [Response scale = 1 (Far below average); 2 (Below average); 3 (Average); 4 (Better than average) and 5 (Much better than average)].

As shown in Figure 3 the mean response was around 3.5, somewhere between Average and Better than average self-rated ability. Proportionately more boys reported having better or much better than average ability, and more girls reported average, below average or far below average ability in science [$\chi 2$ (4) = 79.47; p<0.001; Cramer's V = 0.15]. In particular, the percentage of boys reporting "much better than average" ability was double that of girls.

There was also a significant interaction between sex and school type (single-sex vs co-educational) [$\chi 2$ (4) = 79.47; p<0.001; Cramer's V = 0.15]. The interaction between these two variables is summarised in Figure 4.

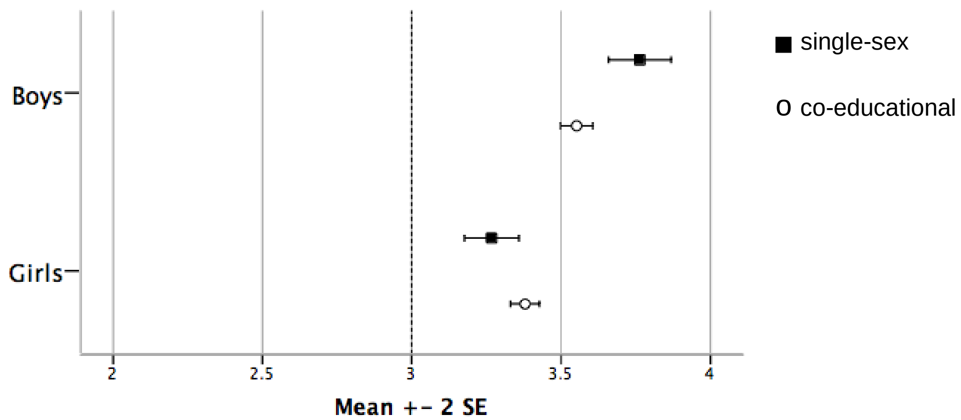


Figure 4. Means of responses to the item "How would you rate your own academic ability in science this year compared to others in your class?" broken down by sex, across school types (single-sex and co-educational. [Response scale = 1 (Far below average); 2 (Below average); 3 (Average); 4 (Better than average) and 5 (Much better than average)].

As suggested by Figure 4, proportionately more boys from single-sex schools rated themselves as "Much better than average", than did boys from co-educational schools and this difference is more than would be expected were there no association between school type and self-rated science ability [$\chi 2$ (4) = 19.85; p=0.001; Cramer's V = 0.10, ASR = 4.0, (p<0.001)].

This pattern was not evident in the case of girls, however, as is indicated by Figure 4. In fact there is suggestive evidence of the converse: proportionately more girls from single-sex schools rate themselves as “Below” or “Far below average” in comparison to girls from co-educational schools [$\chi 2$ (4) = 19.84; p=0.001; Cramer’s V = 0.10: ASR = -2.8 (0.001<p<0.01)]. There is certainly no evidence among the girls for the pattern of higher self-efficacy in single-sex schools seen among the boys, and in fact the tendency is towards the converse.

DISCUSSION

SCIENCE SUBJECT CHOICES

The results of this study highlight the continued importance of gender in students’ choices in and attitudes to science. That relatively few girls in this study chose physics, even among students rating their academic ability as “Much better than average”, is consistent with global trends that are persisting despite decades of research into the underrepresentation of girls in physical sciences (e.g., Adamuti-Trache & Andres, 2008), and at least a decade of emphasising more gender inclusive classroom practices, at least in the Australian context. Various explanations for this have been postulated (Brotman & Moore, 2008), ranging from early differential socialization of girls and boys relating to experience with and consequent liking for scientific tools and activities, to gender differences in the perceived need to conform to gender stereotypes, issues relating to the ‘masculine’ , objective and value-free way that science is portrayed in the classroom and complexities of identity formation. Recent research into the relationship between gender and identity construction (e.g., Eccles, 2009) and other aspects of science culture (e.g., Taconis & Kessels, 2009) appear to be providing useful lenses to clarify and interpret these complex interactions.

DIFFERENCES IN REASONS FOR NOT CHOOSING SCIENCE

That girls in this study reported more frequently than boys opting out of science because they could not picture themselves as a scientist, perceived themselves as not good at science, and perceived science as more difficult than other subjects forms a coherent picture consistent with previous research findings.

The issue of not being able to picture oneself as a scientist is of particular interest as this was the most frequently endorsed reason for not choosing science for the entire cohort. Girls have previously been found to be less likely than boys to envisage themselves as scientists (Steinkamp & Maehr, 1984) or to report that they would like to become a scientist (Schreiner & Sjøberg, 2007). A study by Fielding (1998 cited in Osborne 2003 p. 1063) found that even very high achieving girls did not view science careers as appealing. It has been argued that contemporary youth, particularly girls, develop through a series of choices an identity that does not involve science, which purportedly clashes with current societal ethos of self-realisation (Schreiner 2006 cited in Taconis & Kessels, 2009). A related perspective holds that students’ inability to picture themselves as a scientist relates to clashes between their own self-image and their negative perceptions of peers fitting the “science prototype” (Taconis & Kessels, 2009). Our findings highlight gender differences in this process that have received relatively little attention and warrant continued research.

That girls opted out of science because they were ‘not good at science’ to a greater extent than boys is consistent with their lower self-rated ability in science. It is not consistent, though, with recent reports suggesting that girls’ abilities in science and science performance are on a par with boys (Hyde & Linn, 2009; Brotman & Moore, 2008). For example, although there were some differences in boys and girls in different aspects of science, Thompson & De Bortoli (p. 68) found no statistically significant difference between scores of 15 year old Australian boys and girls in scientific literacy. In terms of perceived difficulty of science, studies reviewed by Osborne et al. (2003, p. 1070) indicate that students in general see sciences (especially physical sciences) as difficult, and that the perceived difficulty of science is a major impediment to students choosing science, especially physical sciences. Our findings that girls in particular opted out of science because they saw it as difficult is consistent with recent findings from a recent study of high school students in the UK which found that girls saw biology, chemistry and physics as more difficult than did boys (Bennett & Hogarth, 2009).

LIKING OF SCHOOL SCIENCE

The finding of no meaningful difference between boys and girls on the enjoyment of school science as measured by the 10 item TOSRA scale runs counter to many studies showing that girls hold less positive attitudes to science than boys (e.g., Barmby, Kind, & Jones, 2008; Bennett & Hogarth, 2009; studies reviewed by Osborne, et al., 2003, p. 1063, (Brotman & Moore, 2008)). The gender differences in responses of these Australian students to the ROSE item “I like school science better than most other school subjects” are consistent with responses to this item in culturally comparable countries (Schreiner & Sjøberg, 2007). The lack of statistically significant difference detected in this study of boys’ and girls’ enjoyment of school science *per se* is of interest in relation to the finding that boys endorsed the ROSE item more than girls. While interpretation needs to acknowledge that one finding was from a reliable scale and the other from responses to only a single item, this issue perhaps warrants further investigation. At face value it highlights the relational aspect of students’ enjoyment of science: that boys and girls enjoy science to a similar extent but that girls do not enjoy it in relation to other subjects to the same extent as boys. This may reflect girls’ greater enjoyment of arts and humanities relative to boys, as has been suggested by Jovanic and King (1998, cited in Osborne, et al., 2003, p. 1063). Perhaps girls do not enjoy science less, they enjoy other subjects more.

SELF-EFFICACY

That boys in this study reported higher self-efficacy in science more frequently than girls is in accord with other research including PISA 2006 results (Thomson & De Bortoli, 2008). The differences in self-efficacy found between single-sex and co-educational schools for both girls and boys are particularly interesting. Although the findings supported the notion that higher self-efficacy in boys was more frequent in single-sex than co-educational schools, there is some evidence that high self-efficacy in girls was in fact less frequent in single-sex than co-educational schools.

We would argue that the more frequent higher self-efficacy reported by boys in single-sex schools is consistent with established research models from a number of slightly different perspectives. Such research includes models of the interactions between psychosocial influences and self-efficacy (e.g., Bandura, Barbaranelli, Caprara, & Pastorelli, 1996), and, from a sociocultural perspective, the impact of cultural and social capital (Lyons, 2004). To elaborate, single-sex schools in the Australian context are generally independent private schools, which attract families from relatively high socio-economic backgrounds. In Bandura’s model, higher socio-economic status is linked to higher parental aspirations, which are also associated with children’s higher self-efficacy. From a sociocultural perspective, the cultural and social capital often associated with higher socio-economic status also relate to self-efficacy and enrolment decisions. Hence the more frequent high self-efficacy for boys in single-sex schools is not a surprising result. The question this finding really raises is, why was this relationship not found for girls?

One possible explanation is that girls’ perceptions of their ability in relation to their peers are enhanced in co-educational settings. Given the evidence of relative parity in the competence and performance of boys and girls in many (although not all) aspects of science (Hyde & Linn, 2009; Osborne, et al., 2003; Thomson & De Bortoli, 2008) it is unlikely that girls’ perceptions of better relative ability in co-educational schools are a consequence of better relative performance. What does seem to differ between boys and girls at school is that boys' levels of physical activity and aggression are higher than girls' (Hyde & Linn, 2009). It is possible that girls may be comparing their ability favourably in relation to boys in co-educational settings as a consequence of what they observe in the classroom. In more general terms, to the extent that perceived ability is related to students' developing self-image, having boys as well as girls in the science classroom is a different 'context' of peers against which girls may be establishing a more positive sense of their own ability.

It has been suggested by Brotman & Moore (2008) that a joint focus on identity-construction and curriculum from a situated cognition framework would be a fruitful direction for science education research. The results of this study support this view, and specifically highlight the need for further research into the development of, and relationships between perceived ability, identity and self-image in relation to different school science contexts.

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COSMOLOGY: INTRODUCING THEMES ON MODERN AND CONTEMPORARY PHYSICS THROUGH AN INTERDISCIPLINARY APPROACH

Jose Claudio Reis
UERJ/Escola Parque
guerrareis@tekne.pro.br

Andréia Guerra
CEFET-RJ/Teknê
aguerra@tekne.pro.br

Marco Braga
CEFET-RJ/Teknê
braga@tekne.pro.br

ABSTRACT

This paper is the result of an experience developed in elementary school, aiming to introduce Modern and Contemporary Physics themes from a historical-philosophical approach. The proposal was performed during one school year with 10^{th} grade students during 36 weeks. The purpose was not to introduce a new methodology but to privilege a historical-philosophical approach as to make the knowledge dealt with in Physics classes in elementary school more significant. In order to evaluate the consequences of this pedagogical experiment a qualitative research was developed. The data collected by the teachers through films, photos and notes during lessons.

The purpose of this paper isn't to evaluate how much physics the students have learned. What we want only to evaluate is the impact of the cultural approach. Therefore, it is difficult to quantify how much the students learned about science, history, philosophy and art. But we can say that this cultural approach allowed the teacher to discuss science in a different way. The students had an opportunity to think about the scientist's work, recognizing that the scientist isn't a man isolated in his laboratory discovering the truth about the Universe. The scientists which the students studied in the course do right and wrong things like a common man.

Keywords*: Science Education, Interdisciplinary Approach, Nature of Science, History, Philosophy.*

INTRODUCTION

In Brazil, the study of Physics in both elementary and high schools does not contemplate the developments of Modern Physics. The purpose of this paper is to discuss a Physics course developed within a Brazilian school. During this development, the students' scientific horizon was broadened when themes on Modern and Contemporary Physics (MCP) were approached from a historical-philosophical point of view. It is important to notice that our purpose was not only to introduce new themes of MCP but also to allow a discussion of contemporary themes through a cultural perspective, stimulating the students to think about the process of knowledge construction. We want the students to be able to recognize science as a knowledge constructed by people immersed in a specific culture.

Science teaching in primary schools must be stimulating so students develop a keen interest in science and perceive the philosophical and cultural implications of scientific knowledge (Mathews, 1994)

In order to do this, we pursued two paths which converged for a common objective. The first path was to use MCP themes from an interdisciplinary perspective, privileging the cultural context of different periods approached in the lessons. In such a way, the construction of an historical panorama allowed students to understand that scientific knowledge is immersed in an environment with which there is a symbiotic relation: scientific knowledge simultaneously builds this environment and suffers influences from it.

MCP themes are important in Physics lessons in high school as they allow students to apprehend certain subjects, providing them tools to understand the surrounding technology; these themes are also important in order to develop greater knowledge on what Physics is doing nowadays. (Terrazzan 1992; Stefanel 1998; Osterman, Moreira 2000).

The second path used for the introduction of MCP themes was to render problematic the classical vision of the world, and therefore discuss the philosophical and conceptual transformations which were implemented by Physics in the 20th century as the discipline explained the universe functions.

The proposition we developed overcomes a technical approach in which the emphasis of Physics teaching is in resolving exercises. In contrast, we discussed with the students how scientific knowledge was built through the centuries, particularly the knowledge on celestial bodies and their movements and origins. The privilege for an interdisciplinary approach allowed a dialog between science and culture, perceiving Physics itself as a part of culture (Zanetic, 2006).

The historical approach was done in such a way as to outline how humans built explications for the way the universe functions.

METHODOLOGY

Since 1993 a group of teachers and researchers in science education from Rio de Janeiro-Brazil (Teknê Group) works on the construction of a program with a historical-philosophical approach for science education. The Teknê Group argues that the introduction of an approach of History and Philosophy of Science in the program could allow the discovery of new paths in this direction. As History and Philosophy of Science become widely perceived as parts of culture, it is possible to cross boundaries between different forms of knowledge (Fleck,1981)(Kuhn,1996).

In Brazil the school content program is open. There are parameters to guide the work of teachers, with skills and abilities that are expected of students at the end of a learning period. However, there isn't an enclosed table of contents to be taught. Therefore, it is possible to introduce new contents in the program. The Teknê Group develops educational practices in Brazilian schools, allowing students to learn new contents like cosmology, and constructing a more signifying and stimulating approach for Physics lessons.

The pedagogical propose was carried out in a 10th grade class during 36 weeks. In that grade, the school has 3 classrooms, each one with 33 students, aged 14 and 15. Most students belong to the middle class and live in several different neighborhoods of Rio de Janeiro The students have 4 fifty-minute periods every week to study physics. Cosmology was studied in only one of those periods, whilst in the other periods the students had optical lessons. Hence the teacher, a member of the Teknê Group, had fifty minutes a week to work with the students. The teacher occupied the time presenting the subject, correcting the exercises and applying evaluations of the students' work.

We chose to work with this grade because, in Brazil, this is the first time that students study physics formally. So this is a good opportunity to discuss themes that stimulate the imagination of the students, like the origin of the Universe.

This school has a program that stimulates a cultural approach. The students have theater, cinema and environment project classes. The teachers were stimulated to bring new pedagogical experiences to the classroom.

In order to evaluate the consequences of this pedagogical experiment a qualitative research was developed. The class teacher was a member of Teknê´s Group and became also a researcher. Another member of Teknê's Group watched the work to the teacher during 36 weeks. This researcher joined the class two weeks before the beginning of the project itself. This previous contact had two objectives: the first, to get to know the reality in which the project would be carried out; and the second to ease the possible feeling of discomfort/strangeness from the students in relation to the presence of someone new in/to the group. Data was collected through films, photos and notes made during the lessons. As the researcher joined the group of students, it was possible to register the students' participation in and out the classroom.

The teacher kept a diary in which he registered his impressions of the class after each meeting. The teacher's and the researcher's registrations and the films were discussed with the project group weekly. This way of interacting resulted in a pedagogical proposal with an initial plan, but which was constantly reoriented.

THE COURSE

The main purpose of the cosmology course described above was to discuss the contemporary models about the origin of the Universe. Researches show that students have a wrongful idea of science (Abd-El-Khalick, Lederman, 2000; Fernandez 2000; Gil-Perez et al., 2001). For them, science is performed by a special man who works alone in a laboratory, discovering the truth about the Universe. With this idea, the students hope that the science teacher will tell them the truth about the Universe. Thus for the students it is difficult to recognize that cosmology models weren't built randomly, and that these models do not mean that we have the truth about the origin of the Universe. With models we can explain how the Universe began without considering God's creation. To overcome this difficulty, we built the course with a historical approach. The proposal is to allow students to understand that scientific knowledge is immersed in an environment with which there is a symbiotic relation: at the same time scientific knowledge builds this environment and also suffers influences from it. So the truth is temporary, but scientific knowledge isn't random.

With these considerations we divided the course in five themes.

1- Classical and Middle Age Astronomy

The first theme discussed was Greek and Middle Age Astronomy. Here, the focus was upon the ideas of Aristotle about how the universe functions. The students understood that Aristotle considered the Universe separate in sublunar and supralunar worlds. All things in the sublunar world were constituted by four elements (earth, water, air and fire). With the natural and violent movement classification, the philosopher explained the movements that occur in the sublunar world. In addition, we discussed how Aristotle based his movement explanation on the observation of nature, but also that he didn't make experiments in the modern sense. Then, the Ptolemaic system was used in order to comprehend Middle Age Physics and Astronomy.

The Ptolemaic system was studied as a good way to describe celestial movement and also as anticipation on the knowledge about celestial bodies. At this point, the European cultural context in the Middle Age was discussed with the students. To do this, we developed activities in which some medieval paintings were showed. The spatial conceptions in medieval paintings were approached in order to outline the hierarchical concept of space, and to explain to the students how this was coherent with the vision of natural philosophers which based their ideas on Aristotle (Edgerton, 1993).

2- Modern Astronomy

To begin the study of Modern Astronomy, the students saw the film "The Name of the Rose" based on Umberto Eco´s homonymous novel. Using the film to illustrate the changing European world, the teacher selected some scenes to discuss the European society in the 12th century. The students understood how a new way of constructing knowledge was being formed. In that cultural context, some people argued that in order to understand something it is important to do empirical investigation, to ask the nature of how things occur. The dialogue about the film was used to outline the dialogue between the Arabian and European cultures, and how this dialogue put the European in contact with new techniques, like windmill and horse harnessing.

After the debate about the film, the students were again asked to analyze medieval paintings. The teacher compared medieval pictures with the paintings of Giotto and his followers, showing that a new arising spatial concept was being formed along with the changes in society. After Giotto, the artists built tri-dimensionality and spatial infinitude (Edgerton, 1993).

The film's activity was a special moment in the course. The film showed a world far from the students. We used this moment to discuss the role of the Church in the development of the modern science. The students became very enthusiastic with the lessons and some of them were amazed with the Franciscans that appear in the film. For the students, religious people of the Middle Age were far away from science.

In one of the three classrooms, a group of students talked to the History teacher about the activity. They wanted to discuss the relationship between Church and science in the Middle Age.

ACTIVITY 1

The teacher used this special moment to present the Copernican system and compared it with the Ptolemaic. The objective was to discuss those scientific questions which the Copernican system answered better than the Ptolemaic, and those questions which the new system couldn't answer. In this perspective, the teacher asked the students which model is better. 77 students (87,9 percent) said that the Copernican model is best and that the Ptolemaic model is naive. 12 students (12,1 percent) didn't answer the question.

The teacher, then, asked them to prove that the Earth was moving around the Sun. Nome of the students presented arguments to prove that the Earth was moving.

As modern astronomy was approached, we outlined the difficulties to accept the Copernicus system due to the lack of physics suitable to replace the Aristotelian physics. With this, students were able to perceive how the permutation of positions between the Earth and the Sun was no easy task.

After discussion, the teacher asked the students to write a text, in groups of three, comparing the two astronomical models. 55 percent of the students said that there was a necessity to propose a new way to explain the movement of bodies in a world in which the Sun was the center. They didn't know how to explain, but they realized that Aristotle explanations were not good enough and some change in the physics were necessary to accept the Copernican model.

3- Classic Physics

In order to study Newtonian physics, the teacher discussed the 16th century cultural environment in Italy. Renaissance paintings were used to illustrate the perspective technique, emphasizing that the artists didn't represent a hierarchical world in their paintings. In this new representation, space was infinite and there wasn't a separation between the terrestrial and the celestial world. For example, Leonardo da Vinci painted a scene, "The Last Supper", which was represented several times by medieval artists. In the medieval paintings Jesus was represented in a bigger size in order to put him in evidence. Da Vinci, on the other hand, built this emphasis by putting the vanishing point inside Jesus' face. The size of the figure in the painting only obeyed the perspective technique. The space in the Renaissance painting was homogeneous, infinite and isotropic. The sky and the earth were painted with the same color. Beside this, the teacher discussed with the students the role of technique and mathematics in the 16th and 17th century (Janson, 1995).

ACTIVITY 2

The teacher presented two pictures to the students (figure 1 and figure 2). He asked them what the meaning of those pictures was. 100 percent of the students recognize the moon in the figure 1. But the figure 2 was not identify.

"I see a bacterium into a microscope". (student)
"It's a little boy on the top of a mountain" (another student)

In order to systematize the discussion the students read a text written by the authors of this paper. The text presented the world which surrounded Galileo and emphasized his choice to write in Italian, to use the dialogue form in his books, and his thoughts on experiment. Galileo was a citizen who was able to put the scientific knowledge beside the artistic. He studied drawing in Italy. Because he knew the perspective technique he was capable to see, in 1609, craters in the moon with his lunette (figure 1). At the same time, Thomas Harriot (1560-1621) used a similar lunette to look at the sky. He saw the sunspots, but he couldn't see the craters of the moon (figure 2). For him the moon had spots like the Sun. Because he didn't know perspective technique, Harriot couldn't interpret the scale of the dark like a shadow. Only after knowing Galileo's draw he was able to understand what he saw with the lunette (figure 3).

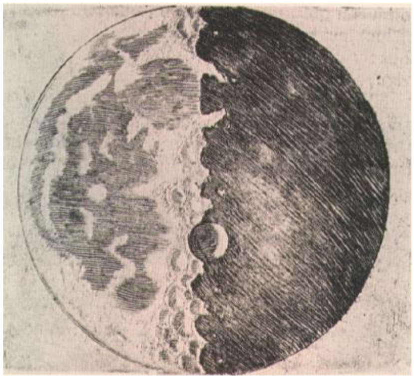

Figure 1-This is the design made by Galileo about the moon's observation.

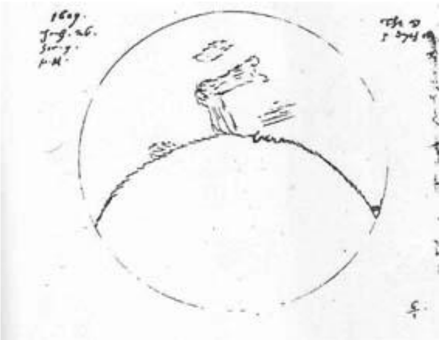

Figure 2- This is the design made by Thomas Harriot about the moon's observation.

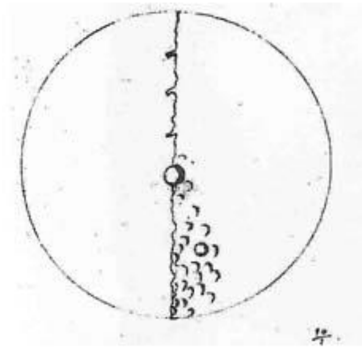

Figure 3- This is the second design made by Thomas Harriot about the moon's observation with the lunette. It's important to note that this design didn't have the quality of the Galileo's draft. Harriot didn't have technique to do a design with the perspective's technique.

After explaining the difference between two pictures (1 and 2), the teacher showed the figure 3. All of them identified the moon. This is a good example of the fact that we don't see only with the eyes. There is an important contribution from the socio-cultural construction to what is seen by people.

Beside the Galileo, students investigated Kepler's work and his desire to construct a physics to explain how the celestial bodies move. Kepler's laws were studied along with the questions that Galileo and Kepler couldn't resolve. The teacher emphasized the need of a new physics to give up Aristotle's and Ptolemy's system.

With this discussion, the Newtonian physics was presented. This study led to discussions on how this new theory allowed answers for all questions which could still persist in relation to the heliocentric system. This new physics was also the possibility to unite the analysis of terrestrial and celestial phenomenon.

Before beginning the fourth theme, the teacher held activities with the students to evaluate the work done so far. With this the teacher wanted to verify if the students had learned the astronomical models discussed in classes, and also the students' views on the construction of scientific knowledge.

ACTIVITY 3

In one of these activities, the teacher gave the students a black box with a hole and a crank. Inside the box there was a mechanical system. The students put a pen in the hole and turn the crank. Then, the pen starts to go up and down.

In the beginning the students insisted to open the box (100 percent).

The teacher explained that it is not possible to open the box. He asked them if it would possible to know what there is inside the box. 66 students (66,7 percent) answered No and 23 students (22,3 percent) answered YES.

Divided in small groups, the teacher mixed the students who had said NO and YES. The students were invited to try to construct a model explaining the box's operation. In order to do this they could manipulate the box, but they couldn't open it. After some time, each group presented its model in the blackboard and argued about their idea.

The teacher used this activity to discuss that, similarly to the black box, nature doesn't open up for scientists. In order to construct scientific knowledge, scientists do experiments, build theories, and construct experiments based on their theories, but they never have nature opened to them. Based on the astronomical models studied in class and in the student's discussions to construct their models, the teacher discussed how scientists make experiments in order to build theories, but not only with experiments have they built their work. They don't work alone in a laboratory to discover how the world works. The culture that they were immersed in was important for their efforts.

4- Kant and Laplace Cosmological Systems

Using the historical approach discussed in the first three themes, the teacher showed that scientists in the 16th century, such as Copernicus, Galileo and Kepler, didn't propose a cosmological theory; they didn't worry about the explanation of the beginning of the Universe. With the Newtonian system the situation reverses.

After the study of the Newtonian system, the teacher explored the scientific and cultural dimensions of Newtonian thinking and its impact on Western philosophy. After the 17th century, everyone considered space as tridimensional, homogeneous, isotropic and infinite. The Newton's Law of gravitation allowed people to understand, with a single explanation, what happens in sky and earth. Scientists now had only one physic for the celestial and terrestrial world. Newton did what Galileo and Kepler looked for with their work, a single physics for heaven and for earth.

Immanuel Kant (1724-1804) proposed a theory about the origin of the solar system based in the Newtonian law of Universal Gravitation. For Kant, the Newtonian system provided a model to understand the origins of the Universe. Differently from Newton, Kant didn't suppose that God was regularly infusing nature. In order to explain the origins of the solar system, Kant considers that in the beginning there were random particles in the world, like a nebula. Gravitation attraction joined heavier particles in the middle, and then the Sun was formed. Around the Sun others particles began to circle, and again gravitation attraction put particles in groups that formed the planets.

Kant didn't explain how these particles began to move. Nevertheless, with Kant a new era in astronomy began. He explained the origin of solar system without mentioning theological arguments (Kant, 1946).

In the same way, Pier Simon Laplace (1749-1827) built a similar model to explain the origins of the solar system. For him, in the beginning there was a ring of particles. Suddenly the ring broke and the heavy particles come together because of gravitational attraction, so the Sun was formed. The other particles around the Sun were agglutinating too, as gravitational attraction put them together and formed the planets (Laplace, 1946).

The teachers discussed the thesis of Kant and Laplace. The students had been studying Kant in Philosophy classes, so they knew him as a philosopher. They were surprised with Kant's scientific studies.

The students noted that the two propositions (Laplace and Kant) were very similar. Both of them were based in Newtonian law of gravitation, and both didn't explain how the particles appeared in the first moment. The teacher discussed in class how with these propositions astronomers had the possibility to build an explanation about the origins of the Universe without God's hands. The path for modern cosmology was opened. In this context, scientist didn't have any doubts about the center of the Universe. It wasn't a problem anymore. Now the issue was how the stars had been formed. They built new telescopes to study the stars, which became the first concern, with planetary astronomy in second plain.

5- Contemporary Cosmology

In this topic, the emphasis was put upon the changes in space-time conception brought by Einstein through the Theory of Special and General Relativity. For the study of the General Relativity the teacher emphasized Einstein's consideration that physics laws were the same for all referential. This came together with the idea that space is modified by matter, and that it was possible to think about a curved space around the planets, the stars, and all heavy bodies.

In the 19th century, mathematicians put Euclidian's geometry in question. They built geometry to be used in a curved space. The Euclidian geometry was valid for a plane space. In the 19th century, mathematicians imagined the possibility of constructing a geometry which was able to represent a curved space. They didn't worry to put this space in a concrete way, since for them the most important thing was to think of all possibilities to represent the space. So why not think of a curved space?

The question about space representation wasn't a priority for mathematicians. It was the artists, especially painters, who put the representation of the space in question. The impressionist artists in the 19th century questioned the homogeneous and isotropic space. Impressionists' paintings, such as the ones by Cezanne and Manet, represent scenes in which the space was not homogeneous, nor isotropic. In the same way, Claude Monet put time in his representation (Shlain, 1991).

After the presentation of the Theory of General Relativity the teacher discussed with students two most important cosmological models in the XX century: Stationary Universe and Big Bang.

To begin this study, the teacher showed observations made by Vesto Slipher in 1917 with the new telescopes. Vesto Slipher concluded that the Universe was in expansion. In that moment, there wasn't any theory which supported his observation. Einstein and his contemporaries considered that the universe was homogeneous and isotropic. In this thesis the expansion wasn't possible, and the Universe would be stationary (Crowe, 1994).

The equations derived from the Theory of General Relativity showed a Universe in expansion. Einstein considered that these equations were wrong, and something had to be done. He modified the mathematical expression and introduced a cosmological constant in the equations. The Universe became stationary.

> In the first moment the students were amazed with these episodes.
> "How could Einstein be wrong?" (student)

The teacher used the development of the astronomy discussed in the first three themes to emphasize that the scientist isn't a special man who discovers the mystery of the Universe. His work is immersed in an environment with which there is a symbiotic relation, as at the same time scientific knowledge builds this environment and also suffers influences from it. Facts are important to the scientist, but mere facts don't make a theory.

The teacher discussed how Einstein was wrong and how in 1922 another scientist, Alexksander Friedmann, rejected the cosmological constant created by Einstein and defended that the Universe wasn't stationary. Einstein and the other major cosmologists rejected these hypotheses. Einstein considered, for example, that Friedmann's mathematics analysis was wrong. Friedmann proved to Einstein wrong, but he died in 1925 without the acknowledgment of his work (Singh, 2006).

In 1927, the Catholic priest Georges Lemaitre, without knowing Friedmann's proposal, but inspirited on the Vesto Slipher' work, defended: if the General Relativity was true, there was a beginning in the Universe, a start point. He imagined that all stars were together in a primeval atom and, at some point in time, the atom decay occurred and the history of the Universe began. For him this beginning was "a day without yesterday". In 1927, in the Solvay congress, Lemaitre talked to Einstein about his work; Einstein didn't accept the idea of the expansion of the Universe. For him, Slipher, Friedmann and Lemaitre were wrong.

In 1929, Edwin Hubble (1889-1953) used astronomical data to build a graphic which compared the distance of the galaxies with their velocity. These data allowed him to construct an equation that showed that the galaxies' velocity is proportional to the distance that separated the galaxies. In 1931, Hubble published a paper to defend the expansion of the Universe.

Einstein, in 1931, admitted that the cosmological constant was his biggest mistake. The Universe isn't stationary, and the galaxies are separating from each other.

CONCLUSION

This proposal which privileged the discussion of MCP from a cultural perspective was very well received by the students. In the last class, the teacher demanded the students to do an assessment of the course. In each classroom, the teacher put the students sitting in a circle, and asked them to describe the most important thing in the Cosmology classes. 61 students said that they liked the activities. For them it was the first time that they discussed History and Arts in Physics classes. 45 students defended that the course was good because they studyed a theme that they had seen on television and had curiosity to learn more.

It is curious that there was an initial resistance by them. In the beginning of the course, some of the students asked the teacher about the point to study theories that were wrong. They thought that wasn't necessary to think about the pass in a physics class. But after some activities like the film The Name of the Rose and the black box activity the students became more enthusiastic with the course.

In spite of this enthusiasm, we can't conclude that the students learned more physical concepts than a course without the cultural perspective. The analysis of data taken from films, photos and teacher's notes, shows that students were very participative in classes. They discussed all the themes proposed by the teacher and they didn't refuse to the activities. So the cultural approach allows students to discuss science and its construction process.

The other physics teacher, who managed the optical class, declared that great number of students, around 40 percent, didn't want to do the activities that asked them to. The students asked him why the optical class only discusses physics. They wanted to know who constructed the optical theories and where and how they lived.

The purpose of this paper isn't evaluated how much they learn in physics. What we want only to evaluate is the impact of the cultural approach. Therefore, it is difficult to evaluate what the students learned about science, history, philosophy and art. But we can say that this cultural approach allowed the teacher to discuss science in class in a different way. The students had an opportunity to think about the scientist's work, recognizing that the scientist isn't a man isolated in his laboratory discovering the truth about the Universe. The scientists which the students studied in the course do right and wrong things like a common man.

So we can conclude that the introduction of new contents, like cosmology themes, in parallel to historical, philosophical, and cultural perspectives allowed students to have contact with a more signifying study, providing also a greater articulation between different fields of knowledge.

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DEVELOPMENT OF DIGITAL EDUCATIONAL RESOURCES FOR EDUCATION FOR SUSTAINABLE DEVELOPMENT: THE *COURSEWARE* SERE

Patrícia Sá

CDTFF/ UA – Centro de Investigação em Didáctica e Tecnologia na Formação de Formadores, Universidade de Aveiro

f2390@ua.pt

Maria João Loureiro

CDTFF/ UA – Centro de Investigação em Didáctica e Tecnologia na Formação de Formadores, Universidade de Aveiro

mjoao@ua.pt

Cecília Guerra

CDTFF/ UA – Centro de Investigação em Didáctica e Tecnologia na Formação de Formadores, Universidade de Aveiro

cguerra@ua.pt

Rui Vieira

CDTFF/ UA – Centro de Investigação em Didáctica e Tecnologia na Formação de Formadores, Universidade de Aveiro

rvieira@ua.pt

Isabel P. Martins

CDTFF/ UA – Centro de Investigação em Didáctica e Tecnologia na Formação de Formadores, Universidade de Aveiro

imartins@ua.pt

António Pedro Costa

CDTFF/ UA – Centro de Investigação em Didáctica e Tecnologia na Formação de Formadores, Universidade de Aveiro

apcosta@ua.pt

Luís Paulo Reis

LIACC/ FEUP – Laboratório de Inteligência
Artificial e Ciência de Computadores,
Faculdade de Engenharia da Universidade do Porto

lpreis@fe.up.pt

ABSTRACT

There is a lack of courseware for the teaching and learning of primary sciences in an Education for Sustainable Development (ESD) approach. This shortcoming determined the organisation of a multidisciplinary team with different competences (on Science Education, Educational Technology and Design) for the development of the *Courseware* Ser$_e$ "The Human Being and Natural Resources".

Adjusting some principles of software's development, as far as User Centred Design (UCD) is concerned (Costa, Loureiro, Reis, Sá, Guerra e Vieira, 2009; Guerra, 2007), in an ESD approach (Sá, 2008) and according to relevant science education perspectives (Cachapuz, Sá-Chaves & Paixão, 2004), this multidisciplinary team collaboratively developed the digital educational resource, which integrated several *software* typologies within the educational activities. A full presentation of the development process of this digital educational resource will be done throughout this paper.

Keywords: *Courseware, natural resources, sustainable development**,** science education, primary school level*

INTRODUCTION

In the current world context, the adoption of sustainable attitudes will depend on the understanding each citizen has of the interactions between science, technology and society and how these affect environmental and economic contexts. The volume of scientific and technological knowledge available to mankind today leads to profound social, political, economic, environmental and cultural changes. Science and technology are, therefore, crucial components that allow for the understanding of the multiple dimensions of contemporary problems.

Holistic and systemic understanding of planetary situation and awareness of the importance to mobilize attitudes that promote both local and global change, depends on the understanding of sustainability and of it implications in the educational context. In the United Nations perspective, educating for sustainability is to educate for responsibility, solidarity and cooperation (UNESCO, 2005). Moreover, the combination of Education for Sustainable Development (ESD) and Science Teaching (ST) with a Science/Technology/Society educational perspective (STS) since the first years of schooling appears as an essential condition for a responsible citizenship.

UNESCO guidelines (2005) for education for sustainable development implementation (EDS) highlight teacher training as one of the essential aspects to the practice reorientation. Teacher training will have to be considered as a privileged means for reflection, not only on the contents and the type of interrelations between them but, essentially, on how to take this approach in practice. Innovative practices in this domain are not possible with methodologies based on information transmission.

ESD implementation through information and communication technologies (ICT) used as new learning spaces is recommended by UNESCO (2005). These technology tools, since they allow the exchange of views and sharing of experiences, can be integrated by teachers as a resource of interaction between students and between students and teachers, as mediator and facilitator of science learning. On the other hand, the student's search, selection and arrangement of information, together with the simulation of scientific and technological phenomena (included in the software), can enable exploration and testing ideas, vital in science education, in an ESD perspective (Sá, Martins, Loureiro & Vieira, 2006).

However, according to the *"Science teaching in schools in Europe. Policies and research"* report (Eurydice, 2006), regarding ICT integration in Science Education field, researchers' attention has focused primarily on the use of the computer as laboratory tool and for simulation purposes. In addition, there is a lack of quality resources for science teaching and learning according to an ESD perspective. This led to an effort towards the development of methodologies which, in turn, imply their continuous and intrinsic assessment so that they match the user's needs and capabilities (Gomes, 2000; Guerra, 2007; Sá, 2008). This is the action line that fits the Courseware Ser_e development.

The Courseware Ser_e was designed by a multidisciplinary team of researchers from the Department of Didactics and Educational Technology of the University of Aveiro, in partnership with Ludomedia (portuguese software development company). Created in the context of Science Education, within the framework of ESD, it responds to a need for quality computerised didactic resources for the 1st and 2nd Cycles of Portuguese Basic Educational System (children from 6 to 11 years).The educational resource was designed for student and teacher classroom use, although its exploration can be adapted to other levels of schooling and education contexts, such as non-formal and informal. This computerized educational resource includes a set of educational activities regarding the relationship between human activity, the natural resources use, energy and the environmental, social and economic long term consequences of such use. The activities proposed, the sequence suggested and exploration and learning purposes aim to create the conditions for cognitive confrontation and problem/questions definition.

This paper presents: 1) the development and research methodologies fallowed; 2) the Courseware Ser_e structure and 3) the Courseware Ser_e educational methodology.

1) DEVELOPMENT AND RESEARCH METHODOLOGIES

The development process of the Courseware Ser_e included four main steps:

-Step 1, *Educational guidebook planning*: the first stage demanded from science didactics and educational technology researchers the drawing up of a document establishing the students level, the thematic and didactic purposes, as well as the aspects relating to architecture, navigation and resource screens design. This phase also let to trade mark and patent the courseware, as well as, amongst others, a set of agreements concerning authorship rights.

-Step 2, *Storyboard design*: at this stage, educational activities and disciplinary content, defined in the previous step, were harmonized with the software interaction aspects, particularly the navigation and interface, with the collaboration of the designer and programmer from Ludomedia. As stated by Carvalho (2003), the resulting scenarios are considered essential to the understanding of the resource utilization context and to represent some of the interactive software situations.

-Step 3, *Didactical resource implementation*: this step was divided in two simultaneous stages. Firstly, the technical part, which corresponds to the software design and programming, as well as of its users manual. Secondly, the didactical part, requesting detailed specification of several aspects, in addition to those already specified in the storyboard (as the initial animation and students and teachers' guidelines). Through this task, the multidisciplinary team tested and adjusted the contents of the student and teacher guidebooks, which involved earnest collaboration of all elements, made either in person or online.

- Step 4, *Evaluation*: seeking to assess both the didactical resource as its development process, it occurred transversely through all the stages listed above. At the end of step 2, the storyboard assessment was carried out by external elements: primary level students, basic education teachers and science didactics and technological education researchers. Furthermore, the first Ser_e version assessment was also made during hands-on workshops (with a maximum duration of 120 minutes), trough an evaluation tool - a questionnaire - designed and implemented by team members. Each workshop included a group of potential heterogeneous users of the resource. The tool consisted of 3 parts: the first part of the evaluation questionnaire is divided in two groups with closed questions about the educational potential of Courseware Sere: (a) the first list of issues related to user interaction with the software; (b) the second concerns aspects on activities designed for didactic use. The second part is targeted at open answers and aims to achieve a synthesis on the relevance and potential evaluation of educational Courseware Sere. Finally, the third part, is seeking comments about the working session and evaluation tool (Costa *et. al*, 2009).

The Courseware Ser_e development process was guided by a reference theoretical framework especially centred in Primary Science teaching and learning, oriented by ESD guidelines, and using an UCD method. These were essential to carry out such rigorous research and to guarantee that the usability principles of the software conception were respected.

Taking into account the UCD and usability premises, the team aimed at finding the answers for two research questions: "What are the positive and/or negative perceptions of the "external evaluators" concerning the storyboard?" and "What are the potentials and constraints that emerged from the methodology adopted in the development of Courseware Ser_e?".

A qualitative method, of a descriptive and exploratory nature, was adopted in order to develop and evaluate the technical and didactical quality of Courseware Ser_e (question 1), as well as, the potential and/or constraints of the methodology adopted in its development (question 2). The development and research study was divided in two research phases, each with a set of different techniques and instruments to collect and, subsequently, analyse the data (Bardin, 2000; Bogdan & Biklen, 1994; Carmo & Ferreira, 1998). As far as data collection is concerned, throughout the process of Courseware Ser_e development, the researchers chose participant observation as well as interviews, questionnaires and the analysis of teachers' diaries.

Data analysis allowed us to identify the positive aspects of Courseware Ser_e, which are related to the educational potential of such a teaching resource in the teaching and learning of Science. Nevertheless, the external evaluators also identified negative aspects, mainly those connected to the conception of some scenarios, namely: some graphical elements are not very perceptive; the interactivity of some screens should be increased; some contents presented may be too complex for students of the first cycle and the vocabulary used may be difficult to understand for some students.

It was also possible to qualify the potential of the work within a multidisciplinary team, for example, the appropriation of several elements for the conception of the storyboard. The participation of external evaluators was also identified as a positive aspect in the stage of Courseware Ser_e storyboard development.

As far as teamwork was concerned, the obstacles identified during the evaluation were mainly related to the communication process amongst its members. The study undertaken contributed to the improvement of the storyboard, as well as of the strategy adopted in the development of Courseware Ser$_e$, previous to the technological conception stage.

2) COURSEWARE SER$_E$ STRUCTURE

Courseware Ser$_e$ is the result of the above mentioned steps and aims to: 1) promote understanding about humans' activities impacts on natural resources and 2) promote awareness about the humanity's future dependence upon the adoption of more conscious and responsible attitudes and behaviours towards energy sources use.

This didactical resource integrates several software typologies (such as modelling and simulation), with didactical activities specified in teacher exploration guidelines. This courseware is constituted by: i) an educational software (CD-ROM and *on line* versions, *demo* version in http://sere.ludomedia.pt/); ii) teacher exploration guides; iii) student registers and iii) user technical guides.

The online software version enables interaction with a social networking platform (Moodle), where users (students and teachers) can access a scientific glossary and database, specifically created to provide access to multiple documents, videos, and others documents. This platform was developed in order to allow user's communication and collaboration among each other and with the multidisciplinary team.

Teacher exploration guidelines suggest several possible activities to work with the courseware and are structured as follows: i) presentation and educational purpose; ii) exploration context and, iii) exploration methodology. These guidelines were developed in order to provide several educational activities leading to science classroom courseware integration.

Courseware Ser$_e$ structure is essentially organized in two interrelated Phases that represent specific problems caused by energy natural resources unconscious use, namely oil and forest.

Figure 1 - Examples of some screens of the *Courseware* Ser$_e$

Phase I main purpose is for students to research various aspects related to oil production and consumption, to point out oil reserves and consumption levels in a world map, and to identify these natural resources uses in diverse daily situations. This energy resource finitude and the impossibility to generalize today's consumption levels to all the planet's inhabitants will raise subsequent problems and the forest use appears as an alternative energy resource (***Phase II***). However, the social and environmental impacts emerging from this energy resource use, as well as forest imprudent management and renewable resource scarcity raise the third question/problem: Which are the alternative future energy sources? (***Phase III***, in development)

In between Phases, the users/students role will consist in information research, selection and organization, having Discussion Forums available, which allow for the sharing of information gathered by each group, but also to a more coherent next Phase, in a contextualized transition process.

To conduct this research and to guide the establishment of the necessary relationships and interactions between population and resource use, 8 characters were created - 6 explorers and 2 team coordinators (**Figure 2**) – that can play different roles throughout the entire situation, particularly escorting each of the groups during the various activities.

Figure 2 – Explorers and team coordinators

3) COURSEWARE SER$_E$ EDUCATIONAL METHODOLOGY

The start of the Courseware use is intended to be through the exploration of a context situation. A *movieclip* was developed relating the human being with the natural resources use. The impact of several natural resources use comes out as an initial problem for the courseware exploration. This is a four minute *movieclip* presented by 2 team coordinators and intents to be the starting point for an inquiry strategy that will motivate 6 “explorers” of the international company to study, from a constructive point of view, the use of natural energy resources.

Starting with this context, the arising problem should emerge from shared reflection between teacher and students, providing students with both the identification of their conceptions and the definition of some questions/problems. These questions/problems will serve the purpose of guidelines for the research, and their joint analysis will allow for a better understanding of the initial problem. Each one of the working groups will be responsible for a question/problem, to which a solution should be devised.

Presentation of content and exploration strategies will be made by reference to each of the Courseware Ser_e Phases, previously identified.

Phase I – Oil
The first step of the Discussion Forum will be the joint construction of a question/problem enabling the understanding not only of oil importance, but also concerning the relationship between oil use possibilities and the world's population access. The question suggested in the teacher guidelines states *What will happen to oil if we use it without thinking?*

This question should allow the formulation of sub-questions, which focus on more specific aspects of the problem. This will facilitate the understanding of several related oil issues understanding. Some of the sub-questions suggested are: *What is oil used for?; Where does oil exist?*; *What are its consumption impacts?* and *What can influence the oil reserves?*

In order to construct answers to each of the referred sub-questions, the teacher can organize students according to each one of the 6 explorers. Each group will have to search, select and organize the required information, available in the software and/or in another information sources (Internet, books…). The constructed results will be presented and discussed in a following stage during the Discussion Forum.

The goals of ***Phase I*** Discussion Forum are, on one hand, to highlight the relations between oil consumption, oil reserves location and consumers number and, on the other hand, to raise the question about the referred interaction: *What will happen to oil if we use it without thinking?*

After this Forum, the information gathered by each group should enable to present the characterization of the current oil situation. According to this, the teacher should lead the students to the identification and separation of conditions that influence the future availability of this resource, namely: oil reserves, developed countries levels of consumption and consumers number. This conditions individualization allows for their co-relation, facilitating the understanding of the combined impact of the consumer's number and the levels of consumption. Thus, from this identification, it is possible to arrange a simulation organized plan based in Goldsworthy and Feasey's planning chard (1997):

i) *What will we modify*? A: consumers number
ii) *What will we maintain*? A: consumption levels
iii) *What will we measure*? A: deposit oil amount
iv)

Simulation use allows for the establishment of relationships between the consumers number and deposit oil amount, when consumption levels are maintained equal to all consumers.

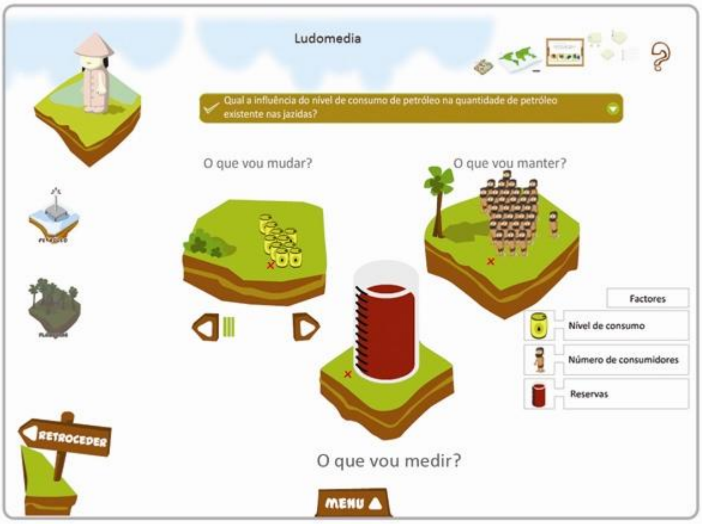

Figure 3 – Oil consumption simulation

Phase II – Forest
This Phase has as several purposes: to promote the understanding of forest diversity; to perceive that forest local use is influenced by population social-economic context; to recognize the forest variety, understand its environmental, social and economic value and to perceive that the forest is a renewable natural resource.

Exploration of Phase I will result in a systematization of information regarding different oil use possibilities and its related multidimensional impacts. The purpose of the new Discussion Forum is to generate shared reflection about oil energy alternatives. At this stage, explorers are required to consider the oil use information gathered so far, and to identify energy alternatives found by the people who can not access oil and take advantage of its several uses. Wood emerges as one of the main alternative energy resources, along with and a new question to debate: *How is forest used by human beings?*

Resembling Phase I, this initial question should allow for the formulation of sub-questions during the Discussion Forum. The suggested sub-questions are: *What is forest used for?*; *Where are the main forests located?* and *Which will be the wood consumption impacts?.*

To answer each one of these sub-questions, the groups, following their respective explorers, return to their original region. There, they will be confronted with new problematic situations whose resolution requires the use of local wooded and non-wooded products.

Phase II Discussion Forum will allow for the characterization the use of products from local forests. Each group of students shares information regarding the characterization of the visited local, enabling the others to "see" another reality. However, the students will also be confronted with the forest depletion possibility, despite it being a renewable natural resource. The question *Which are the future energetic alternatives?* leads to the transition to the next Phase, which is presently being designed by the original team members of this project.

CONCLUSIONS

Courseware Ser$_e$ is the result of a multidisciplinary team work, emerging from combined research, development and practice. For its characteristics, the team considers it a value contribute to ESD. It's a based didactical resource, with several validations. It has several activities variety in continuous development. It's an active citizenship support resource, through the possibility of several competencies development. It has a teacher training programme to support its exploration.

This didactical resource has been subjected to several iterative evaluations (Costa *et al*., 2009; Guerra, 2007; Sá *et al*., 2008), and is the resulting work of the authors expertise and the final users contributions (as well as Science Education experts), allowing to the identification of its shortcomings and to the (re)elaboration of detected fragilities.

Since Courseware Ser_e is based on ESD principles as designed by the UNESCO - didactical issues/questions based in nowadays problems (sustainable development); interdisciplinary perspectives and information and communication technologies integration – it's the team's intention that this didactical resource can serve the purpose of being one valid contribute for the United Nations Education for Sustainable Development Decade.

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TEACHING EVOLUTION IN A MULTI-CULTURAL SOCIETY: TEACHERS' CONCERNS AND MANAGEMENT STRATEGIES FOR COPING WITH CONFLICT

Martie Sanders

Animal, Plant, and Environmental Sciences,

University of the Witwatersrand

Martie.Sanders@wits.ac.za

ABSTRACT

The introduction of evolution as a new topic in the externally-examinable Grade 12 *Life Sciences* curriculum in 2008 in South African schools raised serious concerns amongst teachers about potential controversy between religious beliefs and evolutionary theory. The problem is exacerbated in South Africa, where most schools are multi-cultural in terms of religious beliefs. Semi-structured interviews with 25 teachers after two years of teaching the new topic showed that although many concerns had been allayed as teachers experienced the reality of teaching evolution and developed their subject matter knowledge and pedagogical content knowledge, managing the controversy was not easy. An analysis of management strategies identified approaches which successfully alleviated concerns (of teachers, learners, and parents) but showed that some approaches promoted controversy. Stereotyping teachers and their likely approach to teaching evolution, based on their religious affiliations, was shown to be inappropriate. A model of factors influencing the potential conflicts when teaching evolution can help teachers, teacher educators, and curriculum developers to ensure learners get a fair deal, from the point of view of respecting religious beliefs and in ensuring they are taught the science of evolution fairly.

Keywords: *teaching evolution, managing conflict, multi-cultural religious beliefs*

THE CONTEXT OF THE STUDY

The inclusion of evolution in the new South African school curriculum

A new curriculum introduced incrementally in South African schools from 1998 to 2008, included the implementation of nine new classroom practices (Sanders and Kasalu, 2004) and added several new topics in the various sciences. One new topic introduced into the final year of the senior *Life Sciences* curriculum was evolution, which makes up 25% of the Grade 12 curriculum and the school-leaving examination for *Life Sciences*. Three important reasons are given to support the increasing efforts being made to include evolution in school curricula worldwide. Firstly, evolution provides a framework which allows biologists to understand many of the fundamental principles and processes which explain the living world. As pointed out almost forty years ago by Dobzhansky (1973: 125), insights in biology are so grounded in an understanding of evolutionary theory that *"nothing in biology makes sense except in the light of evolution",* and more recently the National Academy of Sciences (2008, ix) reiterated that "[e]*volutionary biology has been and continues to be the cornerstone of modern sciences*". Secondly, because evolution has increasingly been seen by biologists as a central theory of almost every branch of biology, and applies in many related sciences, evolution provides what biologists consider to be a powerful unifying theme across scientific fields (Clough, 1994). Thirdly, an understanding of evolutionary theory has allowed scientists to devise applications in medical, agricultural, conservation and management, and other fields, and these applications have radically improved the quality of human life in many ways.

Learner-centredness, and its importance when teaching evolution

One of the nine new requirements of the South African school curriculum is that lessons become more learner-centred (Sanders and Kasalu, 2004). Many South African teachers do not fully understand this requirement, focussing only on the idea that learners should be more actively engaged in, and responsible for, the learning process, displacing the teacher as the centre of learning (Sanders and Kasalu, 2004). This is the focus of activity-based learning, another of the nine requirements. Much literature on learner-centredness (e.g. McCombs and Whisler, 1997; Dimmock, 2000) focuses more on teachers knowing about and accommodating learner differences when planning and conducting lessons, so that individual learners are provided with appropriate opportunities for learning and self-development (McCombs and Whisler, 1997). The differences referred to include cultural backgrounds, languages, preferred learning styles, interests, abilities and needs (McCombs and Whisler, 1997). In today's multi-cultural classrooms learners may come from different cultural backgrounds and have differing customs, values and points of view (McCombs and Whisler, 1997). Dimmock (2000) points out that knowledge is culture-bound, and that the ideas considered worthwhile in one community may not be regarded that way by members of a different culture. He explains 'culture' as involving *"patterns of thinking, feeling and acting underpinning the collective programming of mind which distinguishes the members of one group or category of people from another" (*Dimmock (2000, 46). People from different religions can thus be considered to come from different cultures, so guidelines about learner-centredness will also apply to accommodating differences in learners' religious beliefs. However, science teachers need to accommodate cultural differences in ways which do not compromise the scientific integrity of what they teach. This has important implications for the teaching of evolution.

THE PROBLEMS WHICH MOTIVATED THIS STUDY

Multiple problems motivated this study:

1. One problem teachers worldwide face when teaching evolution is the widely held belief that the theory of evolution by natural selection conflicts with the beliefs of many religious groups, in spite of arguments and evidence to the contrary (e.g. Scott, 2000).
2. Great harm is caused by dogmatists at either end of the creationist-science belief-system continuum (see Table 1). Dogmatists disrespect the beliefs and rights of others, insisting that no belief but their own is correct, and often trying to enforce their views on others. In education systems such people are a potential threat to the implementation of learner-centred approaches because they do not respect or accommodate views which conflict with their own.
3. The use of inappropriate strategies for dealing with the potential controversy is a threat to learner-centredness. For example, debates on evolution enforce the notion that there are "right" and "wrong" answers, and that logical arguments followed by voting will reveal the correct answer. Telling "both sides of the story" is also a strategy questioned by those who feel that a science classroom is not the place to discuss religious views, and that doing so means that science is not being given a fair deal.
4. Many South African teachers had expressed a range of concerns about having to teach evolution, almost a fifth of the concerns they listed relating to potential conflicts between evolutionary theory and religious beliefs (Sanders and Ngxola, 2009). These included

concerns about clashes with their own religious beliefs, those of learners, possible conflicts with their school's doctrine, and potential complaints from parents.

5. A fifth problem emerges from literature, which stereotypes people according to their belief systems, and makes generalised statements about how such groups handle the controversy. Such generalizations create false perceptions of the situation in schools, and lead to inappropriate solutions being applied.

AIMS OF THE STUDY

This study had several aims: i) to investigate the various approaches teachers used to deal with the potential controversy when teaching evolution, ii) to see to what extent learner-centred methods are being used which do not infringe on the religious beliefs of certain learners, yet which give science a "fair deal", and iii) to understand and model personal and contextual factors affecting how teachers with firm religious beliefs cope with the potential controversy when teaching evolution.

THE CONCEPTUAL FRAMEWORKS DIRECTING THE RESEARCH

The belief system continuum of Scott (2000) was used to classify the teachers in the study (see Table 1). It places dogmatists at either end of a spectrum, and accommodates along the continuum those with varying degrees of acceptance of religious and scientific viewpoints. Religions originating in the middle East (Christianity, Islam, and Judaism) can be accommodated on this continuum.

Table 1: The creationism-naturalism belief-system continuum of Scott (2000)

<table>
<tr><td rowspan="9">Creationism
↕
Naturalism</td><td>Young-Earth creationists</td><td colspan="2">Interpret religious books literally (the Earth and all living things were created in six 24-hour days, and the earth is 6 to 10 thousand years old). They deny biological descent with modification.</td></tr>
<tr><td rowspan="6">Old-Earth creationists</td><td colspan="2">Accept some scientific evidence (e.g. that the earth is very old, and microevolution) and accommodate some aspects of evolution in various ways.</td></tr>
<tr><td>Gap creationists</td><td>Assume a pre-Adamic creation that was destroyed before Genesis 1:2, when a divine being recreated the world in six days, and created Adam and Eve.</td></tr>
<tr><td>Day-age creationists</td><td>Recognise each of the six days of creation as long periods of time (thousands or millions of years instead of merely 24 hours long).</td></tr>
<tr><td>Progressive creationists</td><td>Accept the fossil record as an accurate representation of history by explaining that a divine being created "kinds" of plants and animals sequentially over a long period of time.</td></tr>
<tr><td>Intelligent design creationists</td><td>Believe complex organisms could not have evolved by chance, and so must have been controlled by an "intelligent designer" – a divine being.</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Theistic evolutionists</td><td colspan="2">Accept macro-evolution, but believe it is managed by a divine being.</td></tr>
<tr><td>Materialist evolutionists</td><td colspan="2">Have a non-religious belief system which accepts only scientific explanations for life and its diversity. Some are neutral to religious ideas, while others say that the supernatural does not exist and thus reject the ideas of creationists.</td></tr>
</table>

To direct and interpret the research on how teachers handle the potential controversy Barbour's four-category model, as applied by Anderson (2007) for teaching evolution, was used. A *conflict* strategy applies when teachers perceive religion and evolution as being incompatible belief systems which demand that a choice be made about which to believe. The *independence* approach is used by those who suggest that the two ways of seeing the world (religious and scientific) are very different, and should be taught in different school subjects. The *dialogue* approach promotes the open and critical discussion of conflicting issues. The *integration* approach allows for misconceptions on both sides to be dealt with, allowing the integration of both views as part of lessons. Knowing about *conflict, independence, dialogue* and *integration* strategies (as explained by Barbour, 1997) was helpful in both structuring interview questions and interpreting teachers' answers in a meaningful way in this study.

METHODS

Twenty-five teachers who had attended three- or four-day in-service workshops in 2007 or 2008 to prepare them to teach evolution, and who had expressed concerns (in a written reflective task) about a potential religion/ evolution clash, were interviewed. Table 2 shows the range of religions and denominations represented in the sample. Nine of the teachers were more than just congregation members at their religious institutions, being involved in the organization of a variety of church activities: one was an Anglican church deacon, and another was the wife of a pastor in a charismatic church. Whilst the remaining 16 teachers were involved only as members of a congregation, five of them described themselves as being deeply or strongly religious. I classified the teachers' positions on the belief continuum of Scott (2000) at the time they started teaching evolution (see Figure 1). Just over half (n = 13) were, at that stage, young-Earth creationists who interpreted their religious books literally, and believed all existing species were created in six 24-hour days.

Semi-structured interviews were used to elicit teachers' views, as they allowed for careful preparation of questions to gather the data I needed (so nothing was forgotten during the interview), but provided the flexibility which allowed me to diverge from the interview schedule to explore interesting avenues arising during the interview. All interviews were transcribed verbatim, and analysed using open coding.

Table 2: Details of the sample for the study

Schools (n = 23)	
School type	**Religious orientation of school**
Government schools = 12 Independent Examinations Board private schools = 7 Private religious schools writing the government exams = 4 (2 Muslim, 2 Christian)	Secular = 12 Secular, but with Christian ethos = 3 Jewish = 2 Roman Catholic = 2 Muslim = 2 Fundamentalist Christian = 2

Teachers (n = 25)		
Religion / religious denomination	**Extent of religious involvement**	**Position on belief continuum when they started teaching**
Hindu = 1 Muslim = 2 Jewish = 1 Roman Catholic = 1 Fundamentalist and evangelical Christian churches = 11 (2 Pentecostal , 2 Apostolic, 3 charismatic; 1 Baptist, 3 other) Mainstream protestant = 9 (5 Dutch Reformed, 2 Anglican, 2 Methodist)	Involved in organization of church matters = 9 Member of the congregation = 16 (5 strongly religious)	Young-Earth creationists = 13 Old-Earth creationists = 8 Theistic evolutionists = 3 Naturalists = 0 Could not be classified (Hindu) = 1

RESULTS AND DISCUSSION

Because a number of factors affected how teachers managed the potential controversy, I start the presentation of results by looking at some of the factors which affected how teachers taught evolution, before moving on to examining the strategies they used.

1. Teachers concerns had largely been alleviated

The most notable finding was that teachers' concerns and fears had abated as their subject matter knowledge and their pedagogical content knowledge improved. In many cases fears which had been expressed had never actually materialised, once teachers got to grips with the content.

Fears about conflict between evolutionary theory and the teacher's religious beliefs. Many of the teachers said that once they started reading more about evolution as they prepared to teach it, they realised that that their perception that the two belief systems were in conflict was an erroneous one. In trying to pinpoint reasons for erroneous perceptions, three factors emerged (see quotes in Figure 1):

- Ignorance about what evolutionary theory is about, and what it says. Many teachers said that they themselves had been ignorant, and also that the public in general lacks awareness. They also came to realise that many claims about evolution were based on misconceptions. Several teachers saw that once they knew more about evolution, they were able to interpret their religious books (Bible, Torah or Qur'an) differently, or that they could use their knowledge of the religious books to understand aspects of evolution and where they fitted into the religious scriptures.
- Inappropriately constructed views about evolution. Eighteen teachers had come to realise their religious organization or leaders had never said anything about a conflict between religion and evolution. Teacher #5 explained "*I have never, ever, ever gone to a church service where they have said that evolution was wrong. Never. As I look back now it (the church) is there for spiritual clarification and not for scientific clarification*". A number said that they thought they had constructed this idea personally, based on their knowledge of the creation story, and their scanty and erroneous beliefs about what evolution is about and inferences that "*evolution is bad*", suggesting that they had put the two ideas together ("*we always assumed, as children ...*" T#7). Teacher #5 explained "*it is not actually what you were told at church, but what you were told in other ways …*"

I have always believed, literally, in what the bible says … and, I think because of those beliefs I have never really delved into evolution ... I don't know if it was a sub-conscious blocking, but I feel I was never educated about evolution. And I have never bothered finding out about it because I believed in creationism. I think because of that my knowledge on evolution was so poor. I was so ignorant about evolution … totally ignorant. … But with it coming back into the syllabus, the more I do [the more I] change in my views. (#2)

I have started to discover that there is this huge wealth of information that scientifically explains the creation around us and does not contradict physically what I read in the bible. And I don't have to go changing and manipulating the bible to try and fit it in with evolution theory because they are completely different paradigms and they don't need to be mixed. (#3)

With all the reading that I am doing I don't believe in the true sense that [the bible] is literal … just like any other book it is written by people who are interpreting what was passed down by an oral tradition, before it was written. So I don't believe in the day-for-a-day theory … because the bible contradicts itself. (#9)

And last year was the first time that I actually had to sit down and go into it. And I realised that what I thought … it was actually wrong. It didn't change my belief system, ultimately ... it was just that I was coming, with my belief system, from a point of ignorance. My belief system hasn't changed at all in that way. How I viewed evolution changed. (#5)

And that was mainly because I really lacked information. You know, if you do not know about something, and you just hear this thing, and you think "hey, this is really bad" and you start getting worried. There are some clashes, I agree, but somewhere along the way I realised "you know, science, is not really saying the direct opposite to our beliefs ... our religious beliefs. It's only that science is giving us the in-depth explanation to what we only knew [before]". (#13)

In 2008 Teacher #10 wrote "This will make me think about leaving teaching, and go into another career." By the end of 2009 she said ". I am no longer thinking about changing my career because of evolution. I do not <u>believe</u> in evolution but I <u>accept</u> it as the best scientific explanation for a lot of the observations about fossils, biochemistry, evolutionary changes we can actually see, e.g. how bacteria became resistant to certain medicines. I thought that man came onto earth about 10,000 years ago … but later on … teaching evolution … I have changed my mind. From that day, I don't know how many billions of years have passed, before Adam and Eve appeared on Earth. I believe that God is in control of it. Whatever happens down here I think God won't be cross with you, if you strongly believe in evolution. (#10)

And up until now, that I haven't been confronted with evolution directly, I never realised that there are so many controversies [misconceptions] surrounding it. (#7)

I think that … you know, what I really, really believe is that people don't know what evolution is, and that is why it must be either / or. (#8)

I do believe that a lot of misconceptions come because we are misinformed or because we have too little information concerning evolution (#7)

Figure 6: Interview extracts, revealing teachers' growing knowledge of evolution

- Misconceptions about what their religion's policies about evolution were. Although every teacher had started off believing their religion was against evolution, many had come to realise that their organization had not addressed the matter (as illustrated in the previous bullet). Three teachers had to approach their religious leader for clarification when their institution had not addressed the matter and they wanted to know. Four teachers said their religious leaders avoided the topic, one stating the leader did not seem to know anything about it, another stating that the leader came to her for information about evolution when he heard she had to teach it and had read up on it. Only three of the 25 teachers said their religious leaders had specifically addressed the matter, and were very much against evolution. Many major church groups (e.g. Anglican, Presbyterian, and Roman Catholic) have openly accepted that evolution does not contradict their religious beliefs.

Complaints from the parents: Twenty-two of the teachers said there had been NO complaints from the parents, a number noting that this was completely contrary to their expectations. Two of them, however, said that although there had been no complaints, they were aware that parents were concerned. Several teachers from township schools mentioned that it was not in the culture of black parents to complain or involve themselves in school matters. Only one school had received a complaint, and this was not the expected objection to their child having to learn evolution, but a complaint that the teacher was openly rejecting evolution in class, and was regularly providing creationist explanations for the science he taught.

Complaints from the learners: Seventeen of the teachers said they had no complaints from learners. The interviews suggested this was because of the way these teachers had handled the potential controversy, as explained later. Four teachers noted that learners had initially expressed *concerns* (rather than *objections*) but that these had been dealt with in ways which alleviated the learners' worries. However, four teachers said they had received complaints. One was from a Seventh Day Adventist scholar; one was in a fundamentalist religious school where the school and the teachers were anti-evolution; two were from the same school where both teachers were resistant to teaching evolution, and what they said gave me the impression they were projecting their unhappiness onto the learners.

2. Stereotyping is inappropriate

A second important finding was that stereotyping of teaching approaches, or ways of dealing with controversy, based on religions or on belief systems, leads to inaccurate claims or predictions about how teachers are likely to handle the controversy.

There is a wide range of beliefs within religious denominations:
Several teachers pointed out that statements about evolution expressed by religious leaders were often their personal views, and not the official view of their religious group. Eleven teachers believed their religious group itself did not have a policy. In the Roman Catholic Church official policies have vacillated depending on the views of the current pope, and the two teachers from Roman Catholic schools gave me contradictory statements about whether the church currently accepts evolution (it does). The Jewish teacher told me that in the Jewish faith various sects, as well as different Rabbis, have differing degrees of acceptance of evolution. The same holds true amongst Muslims, traditionally seen as being extremely anti-evolution. However, they have a system of experts (sometimes the muftis) reading up in all modern fields of science, and comparing modern ideas with the scriptures, often accepting emerging scientific ideas which less informed Muslims continue to reject. Not all Muslim teachers know this.

Belief systems of individuals within a faith vary widely:
Judaism, Islam and Christianity, which are all faiths arising in the Middle East, have fundamentally very similar beliefs about the creation of living things. But it became clear that each religion is not a homogenous group of individuals with identical belief systems. Teachers within each of these faiths were situated at different points along the creation-science continuum, from fundamentalists who saw their religious scripture as the divinely inspired and immutable literal truths, to more liberal teachers who accepted that religious writings are transcribed stories based on scientific knowledge of the times, and which should be seen as writings about faith not intended to explain science. One teacher pointed out that fundamentalists tend to be evangelical, trying to convert all others to their faith. Many fundamental Christian groups erroneously believe that anyone who does not take the Bible literally is NOT a Christian.

3. Teachers managed potential conflict in a variety of ways

Meadows *et al.* (2000) explain that conflict cannot be resolved but can be managed. Figure 2 shows how the teachers managed the situation in ways which allowed them to cope with teaching evolution, when originally they had been very concerned about having to do so. Placing of numbers from left to right in the cells reveals the extent of beliefs. Figure 2 clearly illustrates how inappropriate it would be to predict how teachers will teach, based on their religious beliefs.

	Young-Earth creationists	Old-Earth creationists	Theistic evolutionists	Naturalists
conflict	#3 #2 #2			
independence	#24 #1 #17 #13 #14	#12 #4 #15 #7 #11 #19 #16 #2		
dialogue	#10 #5 #22 #20 #25		#8 #9	
integration			#1	

#6, a Hindu (no problem with evolution), difficult to classify on the belief system continuum, is omitted

Figure 2: Teachers' belief systems, and the strategies they used to manage potential conflict

Conflict:
People in this category see religion and evolution as being incompatible belief systems, forcing a choice about beliefs, so conflict is inevitable. Three teachers fitted into this category. Teacher 3, by deliberately telling learners that evolution is incorrect, and always providing alternative creationist explanations, caused conflict, which resulted in a complaint from a parent about the teacher's creationist stance. However, Teachers #2 and #23 (who revealed elements of an "independence" management strategy) may not have intended to cause controversy, and probably did so inadvertently. Although they taught evolution as an accepted scientific fact, they told the learners there are two sides to the story *and they must make a choice.* Forcing a choice does not allow for co-existence of beliefs. I also wondered whether some teachers (who I did not categorise here) might be promoting controversy by making their religious views (which did not accommodate evolutionary theory) clear to their classes*. "I gave MY point of view about what I believe in so the kids know where I come from and that I am a Christian and respect my views"* (#10*).* Other teachers disagreed, Teacher #7 explaining *"I keep my personal views out of it, as it can lead to a lot of conflict*".
Independence:

This proved a satisfactory way of resolving the matter for just over half of the teachers (n = 13), who suggested that the two ways of seeing the world (religious and scientific) are very different and serve different purposes, and should be taught as different subjects. One teacher explained "*I try to stay away from religion, because I believe, you know, that religion can cause a war. And I try to avoid any conflict in my class".* These 13 teachers stuck to teaching only science, telling learners it was in the syllabus and had to be learned for the exam. Teacher #7 explained "*So I definitely work from a scientific point of view. If I stick to the facts I think that will cancel out a lot of problems, problem areas, and possible unnecessary questions, and even arguments. If I say 'listen, guys, let's keep religion out of this. Let's stick to the facts of what's been discovered', I think I am covered, in many ways. That's what biology and science is about".* These teachers reassured learners that learning about scientists' ideas about evolution should not affect their belief system, and this enabled them and their learners to cope. "*Nobody is out to prove God wrong. It's not about God. It's not about religion. Let's keep that out of this*" (T#7).

Dialogue:
This approach promotes the open and critical discussion of conflicting issues, looking at similarities and differences. Seven teachers were classified as having used this approach. Three of them used the footprint activity from the National Academy of Sciences (1998) [showing how factual evidence can be interpreted in different ways] to initiate the dialogue. "*You know that exercise you gave us with the footprints? We started off with that. And I built on the concepts that they need to understand that some things we can prove and other things we can't – we have to infer from the information that we have got. And that, for them, was fabulous. Then they had to realise that what they thought and what actually happened were two different things, and I think that that actually opened their minds up a bit to what was ahead".(*T#5). Teacher #20 explained *"And then I took them on a journey that … to discuss one's theories is not a bad thing … to realise that we are not all going to see it from the same point of view".* These teachers initiated dialogue at the start of the section on evolution, pointing out that it is quite possible to have different interpretations of scientific evidence. Although they were open to answering questions about religious views during the rest of the course, they focussed on teaching the science for the rest of the topic.

Several teachers had taken pre-emptive steps to allay possible concerns beyond the classroom, either sending out a letter to parents clarifying what would happen, and how they would teach evolution, or addressing parents at a parents' evening meeting and inviting discussion afterwards. However, one teacher said their township school had tried to involve parents by calling a meeting about the teaching of evolution and had experienced great resistance which they were unable to overcome in the short time available.

Integration:
This approach allows for misconceptions on both sides to be dealt with as an integral part of biology lessons. Although this would seem an obvious management strategy for teachers with theistic evolutionist beliefs, only one teacher successfully used this approach. She started by getting learners to identify where they stood on the belief-system continuum. *"I was told about how belief systems can be a barrier to learning, and that is why I do it as one of the first talks, because if somebody is going to start talking about something you don't believe in you put up a barrier…. and you won't engage at all."* Consequently she said *"I try to help people see that there are a whole lot of different positions so that they can try and discover that it isn't just the two fundamentalists' opposites of the spectrum, and to discover that there is middle ground and that there might be intellectual integrity in some of the middle ground."* (T#1).She continued to address both religious and scientific issues as they arose, when she taught evolution.

4. Is everyone getting a "fair deal"?

Are learners getting a fair deal?
Most teachers were unaware that learner-centredness is about accommodating learners' belief systems, or how this is done best. Nine said they did not consider the learners belief systems at all. However, all those using an "independence" approach, because of their own religious concerns, intuitively reassured the learners that whilst teaching evolution there was no intention to change what they believed. Although all but two of the schools (even the denominational ones) had learners from a range of different religions, there was a tendency for teachers to use their own belief system, and that of the majority of their students, as the norm. This was Christianity in the majority of cases. For example, Teacher #2 said she DID deal with other belief systems, but these turned out to be the three Christian systems shown in Table 1.

Reasons the nine teachers gave for not trying to use a learner-centred approach (i.e. accommodating religious differences) included a lack of time and the need to cover the syllabus, large classes, trying to cope with the basics of teaching evolution for the first time, not knowing what the learners' beliefs were, difficulty in designing learner-centred lessons, and not wanting to deal with belief systems as it would cause controversy.
Is science getting a fair deal?

Three potential problems were identified. Firstly, many teachers were not devoting 25% of their teaching time to teaching evolution, as would be expected for a topic making up 25% of the marks. Time spent ranged from just eight hours to 32 hours (four teachers), many teachers spending about 14 hours on it. Secondly, although it is important to deal with potential conflict with religious beliefs, it would be unfair to science to devote too much time to religious aspects. Teacher #3 gave an alternative creationist explanation for every aspect of science he taught. Teacher #20 was immensely successful in dealing with potential controversy, but spent about a week doing so. Thirdly, a number of teachers were not giving science a fair deal because they openly revealed their scepticism about evolution. Seven teachers strongly believed teachers should tell learners what they themselves believe, while seven adamantly said they should not, because this unfairly biases learners against science. Ten teachers taught evolution as an unproven theory (in the everyday sense of the word), some incorrectly saying it was not backed by evidence, or evidence was incomplete.

CONCLUDING REMARKS

Helping teachers to deal with concerns about the potential conflict between religious beliefs and evolutionary theory requires that factors impacting on potential controversy be identified. Figure 3 summarises factors identified during this research. The "internal" factors refer to factors within the teachers, central in the model as teachers lie at the heart of all successful educational endeavours. Four categories of internal (personal) factors impact on how they deal with the controversy: their *beliefs* (including their religious belief system, their beliefs about whether it conflicts with evolutionary theory, and their beliefs about how the matter can and should be dealt with); their *pedagogical content knowledge* (including how to deal with conflict, knowledge of typical misconceptions about evolution, and how to make the teaching of evolution learner-centred); their *knowledge* (of both evolutionary theory and their own religion and its policies regarding the teaching of evolution); and their *practices* (i.e. how they actually apply their PCK effectively in the classroom).

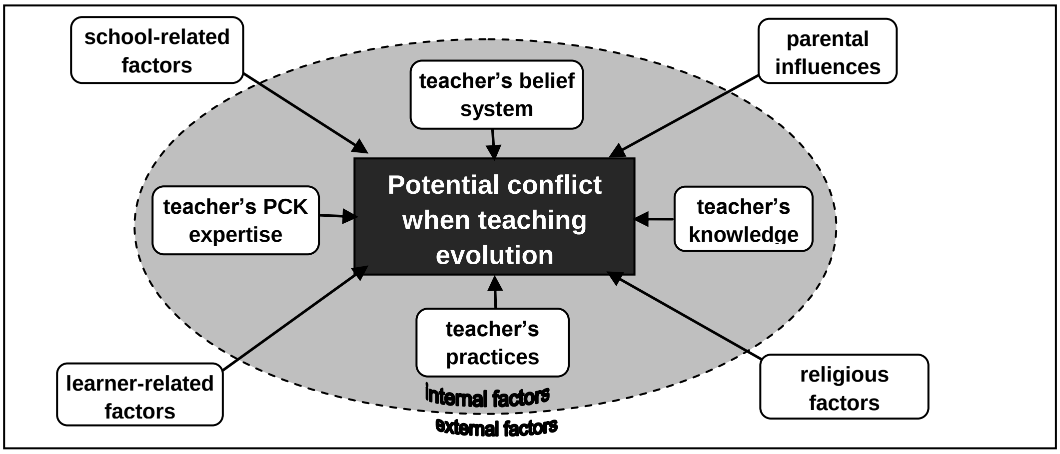

Figure 3: Model of factors affecting how teachers deal with potential controversy when teaching evolution

The "external" factors are those which lie outside the control of the teacher. Four categories of factors were identified in this study: *school-related factors* (school policy on the teaching of evolution, the religious ethos of the school, the heterogeneity of the student body in terms of cultures and religions); *religious factors* (whether the teacher's religious institution has a policy regarding evolution, the impact of the religious leader's personal views); *parental factors* (parents' knowledge, beliefs, attitudes and behaviours regarding evolution, and possible misconceptions they may have regarding the topic); *learner-factors* (similar to those for parents).

The factors identified in this model can place teacher educators and curriculum developers in a more informed position to help teachers cope, by identifying factors which cause controversy, as well as ways of managing it. Although the "external" factors are often beyond the control of teachers, they can be taught to minimize and control such factors, rather than be expected to eliminate them altogether. The "internal" factors are more amenable to control by teachers, once teachers know about them. Some of the strategies used by teachers in this study suggest ways in which potential conflicts can be minimized.

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S&T IN PHYSICS TEACHERS' FORMATION – WHAT IS MISSING?

Anne L. Scarinci

University of Sao Paulo

l.scarinci@gmail.com

Jesuína L. A. Pacca

University of Sao Paulo - BR

jepacca@if.usp.br

ABSTRACT

We studied teachers' difficulties to implement experimental activities in the classroom as a means to a STS approach to physics classes. Data came from teachers' accounts during a professional development program. Our results showed difficulties in maintaining dialogue with the students, when the explanations attempted by them are different from the scientific one; lack of scientific knowledge, by the teacher, deep enough to deal with experimental situations and improvise explanations if unpredicted effects happen; inability to manage experimental apparatus; contrivance to fully control class timing by diminishing students' possibilities to manipulate the device; and clumsiness in orienting the learning process. We conclude that questions related to operating with didactic experiments are at the core of the difficulty to adopt a STS approach to physics teaching. Professional development programs should privilege experimental activities and stimulate their presence in the classrooms, supporting and accompanying teachers as to deal with these difficulties encountered.

Keywords: *Teacher professional development, experimental activities in the classroom.*

INTRODUCTION

The life of any citizen of the contemporary world cannot avoid involvement with technology, much as to comprehend it as to incorporate it in everyday life, benefiting from the facilities and comfort that it brings. Moreover, the use of technology and its development does not come without a social and environmental responsibility, which must also be adequately understood and assumed by thoughtful citizens.

Scientific education is the main formal vehicle of this knowledge and presumes competent teachers for the task (IRWIN, 1998). These must be prepared to face immediate questions of reality, with STS approach, being able to construct with students a culture which appraises the achievements of technology as well as assumes responsibility for their utilization. The questions which apply always have a global and interdisciplinary character, but also demand depth and rigor in dealing with the specific contents.

Paulo Freire (2004, p.83) stated that "what we cannot do, as imaginative, curious beings, is to cease to learn and to seek, to investigate the 'why' of things". In science classes, the STS approach is one of the ways to make learning more meaningful and useful, concerning the needs of a citizen.

A citizen does not act according to a predetermined order, but has autonomy to deal with the possibilities given, assuming responsibility for the future.

> *"I like to be a man, to be human, because I know that my passage through the world is not predetermined; that my destiny is not given, but is something that needs to be done and of whose responsibility I cannot renounce. I like to be human because the History in which I make myself with the others and in which I take part in building is a time of possibilities and not of determinism." (Freire, 2000, p.58, our translation.)*

An approach that connects the discipline taught to the development of a citizen wants to take into account a more open production, not based on a recipe or on something which has been rigidly oriented. In science also, the citizen-being-formed needs to exercise the ability of thinking and constructing, then re-thinking and re-constructing while learning and re-elaborating knowledge.

There is a diversity of ways in which a STS lesson plan is understood, as, for instance, presented by Aikenhead (1992). Santos (2001a) classified them according to greater prominence of aspects of science, of technology, or of society. While in the last one, emphasis is driven from scientific concepts into analysis of social issues, the first two necessarily include a practical knowledge, not only to understand and create technological devices, but also to understand science as a human construction.

Therefore, in these views, experimentation makes a substantial part of the course plans.

One of the ways to connect science with technology in science classes is to relate concepts being learned with devices that can perform a certain task (SANTOS, 2001b). This is easily done with the help of experiments, which allow the construction of a concept to occur through empirical observation and manipulation. In electromagnetism, for instance, experimenting with simple electric circuits can lead to an understanding of both devices as lamps and the concept of electrical current; constructing a simple electric motor is very helpful for the comprehension of motors in general as well as of electromagnetic induction; and building an electromagnet suits for generation of magnetism by an electrical current and interprets many devices of the kind in everyday life. While developing models to explain all these phenomena, the student also re-lives some of the ways in which the science edifice is built.

The importance of experimentation in science classes as a means to science learning is shared by researchers in the area, as well as the many obstacles to effectively insert it in science curriculum (for instance, as synthesized by Pena & Ribeiro Filho, 2006). The importance of experimentation within a STS approach to science requires, from the teacher, more than only a good knowledge of science, as it involves articulation with technology and social issues. How attainable is this is in Brazilian present context?

RATIONALE

The use of experimentation for science teaching is widely researched, but in Brazil rarely implemented in secondary schools, in spite of many courses and workshops on this theme constantly offered to teachers. Why not? Answers may be complex and lie in more than one aspect. We here seek to analyze aspects surrounding teachers' education.

The objective of this paper is, hence, to disclose some of the possible difficulties encountered by teachers who participate in a professional development (PD) program, when they intend to plan experimental activities to teach physics at high school level. From experiments proposed to participants by the PD program, we analyzed teachers' evolution into incorporating in their class plans some kind of experimentation or device-building with students – always linked to a physics content being taught and that can be related to technological and social aspects and to the personal development of the learner as a citizen.

DATA PRODUCTION AND METHODS

The PD program we have accompanied for this research has a format of a continuous formation which accompanies teachers along the school year. It works mainly based on teachers' course plan, helping them to enhance or modify it according to feedback brought from classroom, of students' learning and difficulties. As the program discusses each teacher's planning individually, for cohesion purposes each year or semester the program focuses on one theme (as, for instance, electromagnetism or optics), and participating teachers must be teaching that theme in the period.

The program consists of 13 participant teachers and one experienced tutor, as well as 2 participant researchers. The teachers are from different schools and have from 3 to 20 years of teaching experience.

The routine of the program works in the following way – as the teacher joins the program, s/he is invited to present a course plan for the theme in focus, which s/he intends to use for his classes. As part of the normal chores of the program meetings, the tutor (an experienced University professor) discusses this course plan – individually, with each participant teacher, but in the presence of all the group. Eventually, teachers will have similar course plans, so the discussion with one may be of use for others. As teachers give their classes, according to their lesson plans, they bring the results to the meetings, which are also analyzed and discussed. With this procedure, the tutor can evaluate the teachers' needs to improve their course plans and students' learning, and provide specific activities to address them.

The meetings occur on a weekly basis and last six hours. In the first three hours, participants are discussing their lessons and plans with the tutor. Then the tutor gives them a task (such as to perform an experiment, study a topic of Physics or discuss someone's course plan) that they will perform by themselves during the next three hours. The two participant researchers act as monitors and assist the teachers in this second part.

The data presented here reveal the difficulties faced by each teacher. It was obtained through audio recordings in the PD program, while teachers discussed with the tutor and among themselves the evolution of their classes. Information is always referent to lessons in which experimental activities were to be carried out by the students. In the PD program, these experiments had been worked with and prepared in maximum detail to be included in the lesson plan. Also the course plans were being discussed all through the program and the participant teachers had opportunity to perform the experiments more than once and clarify possible doubts. The program considers that the process the teacher goes through can be at least partly transposed to the classroom.

Analysis was hence done from teachers' accounts during the PD program meetings. These accounts are contextualized in classes teachers have given and in parts of the course plans they're elaborating or re-elaborating (at the time of the accounts).

RESULTS

We present below the main obstacles encountered by teachers from the PD program we've studied, while they were taking experimental activities to their classrooms.

1. HANDLING EXPERIMENTAL APPARATUS

As simple or complicated an experimental activity designed for basic school may be, teachers common skills are more developed in verbal communication and do not generally include managing and teaching with experimental apparatus. This can be a challenge, even when the activity consists only of observation and analysis of materials. The teacher quoted below tried to repeat an activity – analyzing the internal parts of the bulb – at home before taking it to class, and explained why he, then, didn't take it:

> *"I got the bulb to see if **I** could see these connections. Then I couldn't. In any case, I'm not saying that this activity is not nice, I think it's nice, because it stimulates the student to try to find it out…"*

In this other instance, the teacher still has a very standardized idea about the device she asked students to build as homework – a compass – and the student brings another situation which she leaves aside.

> *Teacher – So I told them, 'you take a magnet, pass on the needle, put the cork…'*
> *Tutor – And why not use the magnet directly?*
> *Teacher – Why not use the magnet? Ah, there was a student who did this today. He got the magnet, put in the water, it sank! [laughs]*
> *Tutor – And then he got it out of there and did what? Got it out and put it away in his pocket.*
> *Teacher – Yes, then it is not possible, you see…*

This dialogue extract shows a second degree difficulty, as explanations involved a content that was out of the limits of the theme magnetism, which was in focus. The idea of *floatation* should be brought.

2. WORKING WITH SURPRISING IDEAS OF THE LEARNER

Interpreting phenomena and building models is an essential part of a course plan when one is concerned with learning science as a human construct. When experimenting is performed by teachers to construct scientific knowledge, it allows for different modeling possibilities.

To the students this is equally valid. Obstacles may arise when the teacher doesn't know what to do with student models that may be different from scientific ones. The process experienced by the teacher in the program was not sufficient to guarantee his/her ability in manipulating with the phenomenon, that could be directed to the objectives desired.

In the following account, the teacher allows for students to model the phenomenon from an experimental activity; however he doesn't open space to the random labor of the student because he'd already had an expectation. So, after the students give their hypotheses on how the circuit works to light the bulb, the teacher pushes aside the ones different from what he had expected –

> *"So this issue of the two energies, it appeared, but I kind of directed it, when I put it on the blackboard."*

This represents a situation in which the student is prevented to manifest his ideas because prevented to actually experiment, try situations, seek new possibilities.

For this to happen, the teacher must also experience the "rights and wrongs" while building an apparatus, to also seek, construct, adapt materials and be creative in new proposals. This is what will enable the teacher conduct his students to develop personally. The teacher must have experienced surprise situations, so s/he can admit that students will come up with novelties.

Dialogue is also interrupted depending on the position and function that an experimental activity assumes in the course plan. In some cases, the experimental activity is performed only to "*prove right*" a scientific concept, leaving little space for investigation and none for modeling. In other cases, a very complex experimental device is taken to classroom before students have elements to understand it. The teacher quoted below included the Wimshurst machine in his course plan as an introductory activity in electricity, with intentions stated as –

> *I do not expect very detailed answers, nor the principles of functioning, but only to introduce electricity – I want them to say, "it has to do with electricity, Mister" (…) The [Wimshurst] machine comes more to play, to receive an electrical shock; what they like the most is the shock. Then I want to direct this into studying the electrical current.*

In this situation, dialogue might happen, but not connecting science and technology, for science is not understood and therefore, technology is seen as *magic effects from a black box*. The teacher's account allows us to detect the conception he has of the meaning of experimental work and its possibilities for construction of knowledge.

3. IDENTIFYING CONCEPTUAL ELEMENTS IN AN EMPIRICAL SITUATION

When an experimental activity is suggested by the PD program, the teachers have an opportunity to perform it in the program (analyzing concepts involved) before taking it to classroom. Nevertheless, teachers may be afraid of the experiment "going wrong", *i.e.* of effects being different from the ones planned. They would have to explain something they fear not being able to – teachers fear making mistakes.

Teachers' not being fully aware of the science present in the phenomenon is often masked by their accounts saying that *students* will have comprehension difficulties, as in the following instance:

> *"[last class] I started the voltage concept. But instead of… The [Daniell] battery I didn't do with them. I didn't have the courage yet. It's so complex, the effects… I don't think they'll understand all that. (…) I don't know much of all that chemistry either."*

This may not be a simple lack of knowledge. The teacher may know the concept, but the form in which it will appear in the experiment cannot always be controlled. A very common occurrence is when the teacher is trying to teach a concept and therefore aims too directly at this objective that he loses other nuances of that content, in other forms it may appear in the experiment. This will certainly occur and the teacher fears not being able to identify such occurrences as part of the objective, or as a part of the scientific model that explains the phenomenon.

4. ALLOWING TIME FOR LEARNING

Teachers wish to fully control the timing of the lesson and fear putting an experiment in the hands of students, for this shall lessen that control. When planning an experiment in which students can manipulate, teachers look for *plug&play* kits, which will have almost every part ready so that students have a minimum effort to make it work and teacher will be in maximum control. Also these almost-ready kits lessen the possibilities for the happening of unexpected effects. On the other hand, they also exceedingly limit students exploring and learning.

> *"But instead of taking only the battery and the bulb, and the cables, I got this kit, that has these connectors, and even the bulb can be adjusted into one of them, and the battery; and so the students had only to plug them together. I thought it would be easier for them."*

The teacher takes an almost ready apparatus, leaving little space for action and experimentation. He wants to quickly arrive to the results and with this prevents that the construction process develops.

Another account reveals that the teacher perceived there was more to be explored by the activity worked with. In an experiment of electrolysis of water, she took the experimental materials for the students to manipulate, but had a very directive way of conducting the lesson. After analyzing students' feedback at the PD program, she comments,

> *"I wanted to give an explanation first, but then we didn't have time to… I mean, we had time for what I had planned, but I will take it again, because I saw it was not well worked with."*

The teacher realized that she did now allow enough time for the students to explore all the possibilities of the device, so she took it again to classroom. The teachers become aware that the learner also needs to spend time, as they themselves have done while exploring the activity in the program.

5. CONDUCTING LEARNING

Classroom management in an experimenting class is different from lecture classes, and teachers feel clumsy in orienting the learning process. In a lecture-type class, the teacher can simply expound the content that he has already constructed and previously organized, according to his vision of physics in that situation. In an experimental class, the teacher is forced to relate with reality and so the sequence might have to become more flexible.

In the following extract, the teacher was disturbed with the incapacity of the students in drawing what they had performed in the experiment. The context was building a simple electric circuit to light a bulb.

> *"…Then they noticed that the contact points are all metal. So, but for me this thing is sort of… I am not very much in control of what I'm doing, I'm putting the things, but when I'll explain how it works, sometimes…/ For example, what I did last class – I drew the battery [on the blackboard], drew the bulb and [asked them to draw the cables connecting them]. I saw that many students, even after having done this experiment, made that wrong drawing, of putting [the cables] in only one pole of the bulb!"*

By the reticent speech of the teacher, we can infer he doesn't know what to do in these classes and can't even put the problem objectively in the PD program. In fact he didn't realize that the problem could be in the manipulation itself, in the time designed to the task, and in the attention to the ideas exposed by the students while working to build the device, what would have caused the knowledge construction to be not as correct, or as rigorous as he had expected. As an immediate reaction, the teacher attributes the failure to the *activity being of an experimental kind*, not to the conditions for an effective construction of knowledge to occur.

The quote below refers to a teacher who is trying to understand how to conduct students into analyzing the electrical current and voltage in parallel circuits. He wants to introduce the mathematical equations of equivalent resistance and expresses what he figures out is the difference between his "normal" lecture classes and the new conducting ways he's learning –

> *"So, because in the normal way, in normal classes we depart from there [equations] to here [circuits], then I end up concluding for them that the equivalent resistance is lower in the parallel circuit and greater in the series. So with these activities, it will be the opposite.*

CONCLUSIONS

Although the PD program may work more deeply with some of the obstacles, others depend on the teachers effectively being courageous and reinventing class management abilities while attempting to insert an experimental activity in their lesson plans. In other words, practice is indispensable. As well as, to the student, empirical manipulation is in itself a rich source of learning, discourse and discussions are not sufficient to produce incorporation of new teaching strategies in a PD program. A variety of different forms of practice are required to provide teachers with the confidence necessary – and some of them must be commenced by the teacher.

> *Very* few *people are aware that in* each *of our fingers, located somewhere between the first phalange, the mesophalange and the metaphalange, there is a tiny* brain*. (Saramago, 2003, p. 64)*

There is a lot of knowledge generated through experience. Saramago (*ibid*) also compared the knowledge of the *head's brain* with that of the hands and fingers – the first being general and diffuse intentions of what must be done. A teacher from the PD program stated it as –

> *"In reality, the knowledge you have is always a little superficial, because only when you are there, manipulating the things… there will be things that can only appear in the experiment."*

We have presented obstacles faced by teachers in their classes, in categories which attend to the purpose of structuring and organizing data. However, the reasons for a teacher not to take an experimental material to classroom frequently conjugate more than one category. In the theme optics and waves, for instance, the ripple tank was used by the teachers during one entire semester within the PD program, to produce and study various effects; each participant had even the task of building a ripple tank. Yet, it was taken to classroom by very few. If, in the beginning, reason was that they felt insecure about handling it, then, conducting learning difficulties became more evident, as in –

> *"There are many students and I wouldn't know how I would manage to show the effects to them all. I think it would create a mess, because I'd have to make a demonstration…"*

Overall, teachers are themselves afraid of manipulating experimental devices. In the group we've studied, we observed that as long as the proposal included such simple devices as an electric circuit, teachers could take it to their students, with all the difficulties seen above, after a hard work in the program. But as devices would become more elaborated (as the Daniell battery or the electric motor), fear increased.

With all work done in the PD program, teachers still faced difficulties to handle situations with the students, what we attribute to lack of sufficient manipulation – in terms of investigating empirical situations and experimental apparatus, solving problems by constructing new devices, and then finding new problems…

To avoid surprises or to fully control timing and more effectively concentrate on the phenomenon being taught, the teacher takes almost-ready devices that he thinks will make the process easier for the student. In doing this, though, he limits manipulation and possibilities of verifying other materials or other hypotheses, and examining the situation from different angles. The conception of teaching and learning revealed by this is inconsistent with the broader objectives of forming and developing citizens.

In order to allow space for students, the teacher needs to develop an attitude that *he will find novelties*. Freire, in Pedagogy of Hope (2004, p.123), tells a story of a Swiss teacher who tore a child's drawing because the cat he had drawn could not possibly exist in those colors. Talking to the teacher, the kid's parent discovered that the teacher herself was terrified of situations in which she was demanded to create or decide.

Physics teachers have to find in experimental activities a source of exploration of both phenomena and concepts, of learning and inventing. Within the conception that teachers usually have of an experiment and are capable to take to class (because they were taught in that same way), a more profound form of construction of knowledge is barred, for: *i)* they want to keep the experimental activity within a step-by-step set of procedures – a recipe – and *ii)* they wish to maintain a content organization that keeps physics themes separated – as in the example where floatation could not be thought of in magnetism classes. But technology – and reality – do not see such division.

Allowing the students to manipulate without a recipe is very dangerous if one wishes to maintain a rigid and linear course, with nothing out of the script and no place for the unknown. Many teacher education programs seem to express the same fear, and therefore, exhibit similar conduct.

We believe that questions related to operating with didactic experiments are in the core of the difficulty to adopt a STS approach to physics teaching. Hence, it seems that professional development programs (as well as initial formation programs) should privilege experimental activities and stimulate their presence in the classrooms, without failing to address teachers' obstacles to their implementation, as the ones showed here.

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SUPPORTING TEACHERS, CHALLENGING STUDENTS: SOCIALLY RESPONSIBLE SCIENCE FOR CRITICAL SCIENTIFIC LITERACY

Elisabeth Settelmaier

Curtin University/School of Education; Perth, Australia

e.settelmaier@curtin.edu.au

Peter C Taylor

Curtin University/Science and Mathematics Education Centre; Perth, Australia

p.taylor@curtin.edu.au

Julia Hill

Perth Modern School

Perth, Australia

hilltest@optusnet.com.au

ABSTRACT

This paper presents the results of research into a nationally funded project, 'Socially Responsible Science', in which science teachers developed and implemented *ethical dilemma story pedagogy* in their own classrooms. The research focused on (i) science teachers' success in creating a values learning classroom environment and (ii) the impact on student learning, in particular their development of collaborative problem solving, evidence-based decision making, critical thinking and critical reflection. The research methodology consisted of ethnographic participant classroom observations and interviewing as well as the implementation of a specifically designed questionnaire - the Values Learning Environment Survey (VLES) – to obtain measures of students' perceptions of key aspects of their learning activities. The research results identify key factors shaping teachers' differential design and implementation of dilemma story pedagogy and students' differential engagement in values learning.

Keywords: *socially responsible science education; dilemma story pedagogy; values learning; scientific literacy.*

INTRODUCTION

In this paper we present the results of research into a nationally funded project, 'Socially Responsible Science (SRS)', designed to enable science teachers to better prepare young people for our crisis-ridden world by developing their critical scientific literacy skills. As Hodson (2008) explains, there is growing interest in a 'universal critical scientific literacy' that equips all students with "the capacity and commitment to take appropriate, responsible and effective action on matters of social, economic, environmental and moral-ethical concern" (p. 2). As facilitators of the project we drew on our commitment to a transformative science education that better prepares students to participate as informed members of society and future decision-makers in the science-informed discourse about pressing global issues such as climate change and environmental sustainability. We drew also on our earlier research, based on the pedagogical use of stories for moral development (Vitz, 1990), that had demonstrated the efficacy of *ethical dilemma story pedagogy* for engaging students in values learning in the science classroom. In that study teachers had used specially prepared ethical dilemma stories to engage students in critical reflective discourse and collaborative decision-making on the ethical implications of science and its uses (Settelmaier, 2003, 2009). This innovative approach to socially responsible science education addresses the National Framework for Values Education in Australian Schools and the National Goals for Schooling in the Twenty-First Century, as outlined in the Adelaide Declaration (1999), which argue that Australia's future depends on a solid foundation for young Australians' intellectual, physical, social, moral, spiritual and aesthetic development (Department of Education, Science & Training, 2005). This approach also contributes to the recent call to 're-imagine' science education as an exciting, authentic, investigative and meaningful experience for all students (Tytler, 2007). In this respect, a good ethical dilemma teaching story – like all classic moral dilemmas - has no final solution, thus allowing for prolonged thinking, reflection and learning. Content knowledge – chemistry, biology, physics, mathematics concepts and skills - is essential in order to understand and to find solutions to the ethical dilemmas embedded in the stories. Thus dilemma story pedagogy does not aim at replacing content-based science education but rather aims to enhance its quality and relevance to modern day students by 'adding value' to their learning. During the project, science teachers participated in professional development workshops designed to familiarise them with ethical dilemma story pedagogy and to write ethical dilemma stories relevant to their specific curriculum contexts, to their students, and to local community issues and concerns. The ethical dilemma stories, together with project teachers' implementation notes, are available to science teachers worldwide on the project website: www.dilemmas.net.au. This paper focuses on selected teachers' implementation of ethical dilemma stories in their science classes.

METHODOLOGY

Our research into the teachers' classroom implementation of their ethical dilemma teaching stories was shaped by a multi-paradigmatic research design perspective (Taylor, Settelmaier & Luitel, in press). We employed a mixed-methods approach which included (a) ethnographic methods of participant observation and interviewing and (b) administration of the Values Learning Environment Survey (VLES). The original participants included 8 metropolitan government secondary schools, 22 science teachers, 65 secondary students in Years 9-12 and 17 postgraduate students. This paper focuses on four of the teachers - two female and two male. The research received ethics clearance by the Curtin University Ethics Committee. Participants' identities and schools' names are protected through the use of pseudonyms.

Ethnographic Component of the Research

The ethnographic component of the study involved participant observation of classroom teaching and interviewing of teachers and students. This part of the study formed the basis for the third author's Bachelor of Education Honours thesis. As a research assistant, Julia spent an extended period of time at each school observing classes conducted by the participating teachers. Elisabeth observed all but one of the four teachers' classes. Julia interviewed five students per class and the class teacher and collected the completed questionnaires after they had been administered by the teachers. Students were chosen for interview on the basis of their involvement (or lack thereof) during class and their gender. The quality standards governing this part of the study were trustworthiness, transferability, credibility and fairness (Guba & Lincoln, 2005). Fairness of representation was established through member checking and giving 'voice' to participants as often as possible.

The Values Learning Environment Survey (VLES)

The quantitative component followed standard learning environment research procedure for optimising reliability and validity (Taylor, Fraser & Fisher, 1997). The VLES questionnaire was administered by the teachers shortly after each dilemma teaching episode, yielding 65 useable student responses. The instrument can be accessed on the project website. The VLES was developed with three specific goals: (a) to promote values learning: the instrument provides teachers of science (and other school subjects) with a clearly articulated framework for establishing a values learning classroom environment; (b) to assess values learning: the instrument provides teachers with a relatively simple method for assessing the quality of students' engagement in values learning; and (c) to monitor values learning: the instrument allows teachers and researchers to trace students' long-term values learning development. We designed the VLES in order to obtain measures of students' and teachers' perceptions of 6 key factors of the classroom learning environment that our earlier research shows (Settelmaier, 2009) are conducive to values learning: *critical self-reflection, empathic communication, critical social thinking, deep engagement, collaborative decision-making, teacher support*. Each of these factors became initially a 7-item scale, later reduced to five. We designed the questionnaire in two versions for measuring perceptions of the learning environment as experienced (a) by students and (b) by teachers. Previous research has established that student achievement is optimal when students perceive a close match between their preferred and actual learning environments (Fraser & Fisher, 1983). We incorporated a five-point Likert-type frequency response scale. For readability purposes on the questionnaire we re-named the scales: 'The Dilemma Story' (*deep engagement*); 'The Teacher' (*teacher support*); 'Learning to Work Together' (*collaborative decision-making*); 'Learning to Listen' (*empathic communication*); 'Learning to Think' (*critical self-reflection*); and 'Learning about Science' (*critical social thinking*). Statistical analysis revealed that the Cronbach alpha coefficients lie in the range of 0.76-0.91, indicating satisfactory internal consistency of all scales.

RESULTS AND DISCUSSION

Our discussion of the results focuses on (a) the differential quality of the teachers' implementation of ethical dilemma story pedagogy in their science classes and (b) the impact on students' learning experiences.

Teachers as Facilitators – The Teachers' View

Here we focus on four teachers in three government senior high schools in metropolitan Perth who implemented dilemma story pedagogy in their classrooms. Both female teachers, Delia and June, taught at the same school, whilst the two male teachers, Jeremy and Ron, taught at different schools. Although they had attended the same professional development workshops, it was only the two female teachers who adhered closely to our intended dilemma story teaching approach: *to read out loud or tell freely a dilemma story to the whole class and to pause from time to time for individual student and small-group reflective learning* *activities*. This approach is designed to enable students to identify deeply with the main character in the story and to make decisions on behalf of the character. Delia dedicated several preceding lessons to teaching specific content to her Year 10 class in preparation for the *Western Swamp Tortoise Dilemma story* (see project website for details). June used the *Climate Change Dilemma story* with her Year 12 class as an introduction to a new topic. In contrast, Ron and Jeremy chose to implement dilemma teaching in a more didactic manner: without using a story-telling approach, they presented their classes with dilemma questions only and instructed students to work directly on the questions. Ron presented a dilemma scenario approach related to the topic of *Reproduction*. Jeremy provided his students with a range of loosely connected questions in relation to the topic of *Genetic Counselling*. Thus, dilemma story teaching was not implemented consistently across the sample.

During interviews both Jeremy and Ron seemed to assume that the SRS approach catered more for the teaching and learning of values education rather than for science education per se, as expressed in Ron's comment, "I would have thought it was much more values than science." June and Delia, on the other hand, expressed a view of science and values as being inseparable. In contrast, all of the interviewed students seemed to think that the focus of the ethical dilemma stories was science. Some seemed uncertain as to the concept of 'values' but most interviewed students reported they had been able to apply their science knowledge when trying to solve the dilemmas. Literature on values education (op cit) states that many teachers avoid engaging with values education as part of their curriculum since the curriculum is 'too crowded'.

We asked the four science teachers how they could see socially responsible science education fit into the mainstream science curriculum. Jeremy explained that it was easier to fit ethical dilemma stories "…into lower school classes rather than upper school classes." This was considered to be particularly the case for classes in which university aspirations were low which Jeremy assumed would be the case with his classes and his school. Ron seemed not convinced that this type of learning was 'legitimate science' and admitted that, "I probably wouldn't have done this if you weren't coming." We were surprised to hear this type of comment from somebody who had been involved voluntarily in the project from day 1 and who had attended all professional development workshops. One might wonder as to what motivated Ron to participate in the first place and to agree to participate in the research component of the project. Given his misgivings about the dilemma learning approach, he seemed genuinely surprised that, "…they [my students] were really engaged. They were much more engaged than they usually are!" Both male science teachers thus seemed to have doubts as to whether this type of learning was science and not just a 'waste of precious time'. This stands in stark contrast to their students' opinions as described later in the paper. While both the female teachers felt they would "…not be teaching the full curriculum if values were not taught in the science classroom" and seemed to feel that, "…ethical dilemma stories would be a useful strategy to achieve this". Delia expressed an interest in conducting an ethical dilemma story prior to a unit of study and then conducting it again at the end of a unit of study to see how scientific knowledge helps students form their values. June described the "…values and science as inseparable". It is interesting to note that the two male teachers apparently thought that this approach catered more for the teaching and learning of values education, while the two female teachers I interviewed seemed to view science and values as inseparable.

Students' Deep Engagement with the Dilemma Learning Experience

Students' deep engagement with dilemma stories and the dilemma learning experience is crucial for the success of this type of pedagogy (Settelmaier, 2009). The results of the ethnographic aspect of the inquiry indicated that students' engagement with the dilemma stories seemed positive, and most interviewees described the experience as 'fun' and as 'different' from usual science classes. As Michaela pointed out, "I thought it was really good." Emma, Lee and Phil also seemed to enjoy the dilemma experience as fun and different: Emma contended that it was "…good to learn about how stuff works and there is more to it than just looking at it". Lee elaborated further that "…it kinda didn't feel like science …but it was good to do something different." Phil described the experience further as, " … it was different from a regular class… 'cause normally it's book work kind of stuff. This was different as it wasn't really to do with the books, it was good." Peta, one of the top students in her class seemed to have been able to combine fun with the application of science knowledge, "…it really did help us apply what we have learned in science… and yes, I could use my science knowledge." Only one student reported not being interested in the topic of 'his' story: his class had been engaged in the *Western Swamp Tortoise Dilemma Story* and he was open about the fact that he wasn't interested since "turtles weren't down his alley". This also confirms one of the outcomes of Elisabeth's doctoral research which was that dilemma story topics must be relevant to the students: if students do not relate to or do not fully understand the dilemma in a story, they cannot engage in the necessary thinking and reflection processes. Students commented on the potential of the dilemma learning experiences to 'get people to think' and to 'wake them up'. Some students, like Sam, apparently experienced the dilemma learning experience as a 'wake-up call', "I know for a lot of people it did kind of …umm …wake them up as to who they would choose." Students, like Chloe, also pointed out the connection to real life, "…it could happen, you know, and you would have to face that dilemma." James seemingly referred to a similar 'link between the classroom and real life' when he stressed the importance of becoming aware of how others think and feel, "…if you don't know…you're not going to care. You're not going to know how that person feels." The link between knowing about others' thinking and feelings and caring about others was also explained by Leah who described the dilemma learning experiences as, "…it does teach people values because if you don't know then you don't really care how the other people think about it."Furthermore, students seemed to suggest that this type of learning be included more often in order to teach about the applicability of science to real life. Matt appeared to confirm the importance of using this type of learning repeatedly by saying, "…yes, [it would be good to do this again] because it makes you think about what you do because when I just learned this stuff it was really fresh in my head…just makes me learn the other stuff again and remember it.…and use it in real situations". Matt's statement is supported by Peta who stated that, "…I think it should be done occasionally to help us understand how science is applied more in the real world……in science, the way we learn it, we don't do as many stimulating activities [in relation] to how we'd apply it to the real world". Even Dan who said he didn't normally much enjoy science confirmed that, "…I think it (should be done) a few times."

Summarising, we can say that students' feedback regarding engagement with the dilemmas was generally positive: students commented on the potential of the dilemma stories to 'get people to think' and to 'wake them up', that it was fun and different from usual science classes. Furthermore, they pointed out the importance of the connection to real life. These qualitative findings are also confirmed by the results of the quantitative analysis whereby nearly two-thirds (65%) of the students indicated the dilemma stories were deeply engaging, relevant to their lives, felt curious about the stories, and were keen to solve the problems in the stories. A third of the group was unsure, with one student disagreeing.

Teacher as Facilitator - The Students' View

The teacher's role as a facilitator, agent provocateur, or devil's advocate is vital within our values learning environment. The teacher is more of a guide than a 'dispenser of values'. Given that science teachers often find themselves in the role of the person who 'has all the knowledge', taking a step back and allowing students to engage actively in their values learning can be a challenge, as expressed by two of the participating teachers in their interviews. However, interviews and observations indicated that teachers seemed to receive mostly positive feedback on their facilitator role, their engagement with the students, and for trying something new and different. Student Leah noticed that apparently, "…he [the teacher] was not really comfortable with the new ways…but he did a good job." Whilst other students, such as Matt, confirmed that their teachers seem to act as facilitators most of the time, "…she always teaches us like that. This time it was just more so…!" Students, like Dan, seemed to appreciate the opportunity to speak up and be heard, "…[He] just listened …[and]…[he] let us express our opinions without telling us we're wrong. Students also noted the unique opportunity for their teacher to learn about his/her students, something that apparently doesn't happen normally, as was expressed by Emma, "…because he has basically learned about us throughout the year but there's still some spots that were vague in our personalities that he knew and through this exercise he could really get a stronger vantage point of our character." It was interesting how important it seemed for students that their teacher knew something about them personally.

Summarising our qualitative findings we can say that teachers received positive student feedback on their facilitator role and their engagement with the students, and positive recognition for trying something new and different. Students also seemed to note a unique opportunity for their teachers to learn about them. Furthermore, students appeared to appreciate the opportunity to speak up and be heard without being interrupted or told off for talking. In addition, these results derived through the ethnographic component of the study have been confirmed by the quantitative results where nearly all (94%) of the students indicated that their teachers facilitated their engagement in dilemma story learning activities by stimulating their thinking, encouraging them to participate and accepting the views of others. Only a very small proportion was unsure and none disagreed.

Collaborative Problem Solving and Evidence-Based Decision-Making

Collaborative decision making involves student groups negotiating a decision and/or a compromise in order to solve a problem as a group. Furthermore, students draw on both their own values and increasingly on evidence provided to them through their science learning to make informed decisions. One of the key issues raised during the ethnographic inquiry was the importance of recognising difference in opinions and values and working with it. Students reported that through the group-work and the discussions they seemed to become more aware of different opinions. For some this didn't seem to cause any problems since, as Vicki put it, “I’m used to people having different opinions.” Some students, on the other hand, reported difficulties in the decision-making process due to conflict which may or not have been resolved, like in Julie’s group’s case, “… there was a little bit of conflict in my group!” I think they both just let it go ‘cause they knew they weren’t going to change either one’s idea. So they decided to just stick with their own [opinion].” It appeared that students in her group rather compromised than tried to convince the other person. Students also indicated that knowing about each other’s different opinions did not necessarily cause them to change their own. “After I had listened to other people’s opinion I got what they were saying but I still stuck with mine.” However, in a different school and class, Simone and David had an argument about their difference of opinion that was not easily resolved through compromise. As Vicki, a student who observed the argument, described the situation in her interview, “…she [Simone] got kind of…didn’t really realise why he was thinking that!” To Vicki it seemed that Simone was keen on convincing David that his opinion wasn’t acceptable. Asked later, Simone admitted that, “…I kinda understand why he did it but I don’t really agree with it!” Apparently Simone was still annoyed about David’s behaviour and she added, “…he did it like to cause a stir! He was just being provocative!” It was interesting that Simone described the incident as “… kind of a friendly argument. We were like discussing it, and I was just getting a little bit angry!”, whilst Vicki seemed to have interpreted the situation as a ‘real’ argument. Simone, on the other hand, didn’t seem to mind, “… sure it was resolved but I was okay with it!”. In any case, watching their argument and listening to what David and Simone had to say apparently caused other students, such as Vicki, to reflect on what was being said and on the reasons for doing so. In yet another group conflict was resolved because, “…we were both really accepting it [the difference in opinion]. We have different backgrounds.” Thus knowing each other well seems to have helped with conflict resolution. One student, Dan, stated that it was okay for him to have his own opinion unless somebody else’s life depended on it. Asked to clarify by the interviewer, he said that, “…then I would like other people’s opinions so I’m not just the one that gets blamed for making the wrong decision.” Some students seemed to realise that whilst others have the right to different opinions they personally could not agree with those views. They stated that they had come to understand that both compromises and maintaining one’s own opinions are necessary as this excerpt from the interview with Emma illustrates: *“…* a few things made me …well, the others and what they said…a few things were a bit worrying!” Julia asked for further clarification, “What worried you?”. Emma explained, “…about other people’s priorities and what they would do… like the whole human life or embryo life or something like that…”, and she added, “… [in my group] we worked out some of it but I didn’t really agree with what they were saying, and they didn’t really agree with what I was saying but between them they agreed!”. Julia asked, “…how did it feel with your friends having different opinions from you?”. Emma admitted that she felt, **“…** alone!”, yet with a smile she added, “…it was good having my own opinion rather than somebody else’s!”

Summarising we can say that some students reported difficulties in the decision-making process due to conflict that remained unresolved whilst others seemed to accept conflict as okay if one was convinced of one’s own standpoint. Conflict resolution and compromise seemed to be helped by knowing each other. Yet some students admitted that knowing about other people’s different opinions did not necessarily cause them to change their own. Some apparently preferred the back-up by other people in the case of life-deciding decisions.

The ethnographic results were confirmed by the quantitative results where just over three-quarters (77%) of the students indicated they had worked well together in trying to resolve the ethical dilemmas embedded in the stories, explaining carefully their ideas to each other and striving to reach agreement. A fifth of the group was unsure, and a small number disagreed or strongly disagreed.

Empathic Communication

Here, the focus is on developing emotional intelligence, empathy, the ability to accept and consider other people and their ideas. Most students reported that they felt their voices were listened to and their opinions accepted as legitimate. Students seemed to appreciate the opportunity to hear about other people's thoughts and opinions, and indicated the importance of knowing what others think and feel in order to care.

Sam summarised well what most interviewees had stated, "…it was kinda fun to hear what other people thought… like from their backgrounds…a lot of people haven't been as experienced as I have. " His statement also seemed to imply that he assumed that others lacked his level of life experience and that maybe in everyday life he doesn't have the opportunity (or interest?) to find out about other people's ideas. Evelyn seemed not only more aware of the differences within her peer-group but also of the importance of knowing about others' thoughts when she stated that, "…everyone has different morals and values though and because not everyone is the same … you got to know that." Lee a student who reportedly had little to no interest in science explained that he appreciated the different style of the dilemma story science lesson, "…we were able to converse and look at each others' ideas and we learned a little bit about each other even though we have known each other for years." His views were confirmed by Dan another student who had claimed that he didn't like science much, "…we got to see different people's ideas and what they think about it." It seemed interesting to us that these two students whose initial interest in science was reportedly low had experienced the social aspect of the dilemma learning as a positive learning experience. One of the high achievers, Megan, thought, "…it was good hearing what other people thought and basically putting my opinions towards them and trying to get them to go my way instead of their way." Her statement was interesting inasmuch as she pointed out that she had to formulate and state her opinion to others in a convincing way which suggests the necessity of deep engagement with the subject matter: one must have understood something in order to try and convince somebody else of its usefulness or validity. Yet arriving at a common understanding apparently was not always easy as Simone explained, "…I know there were a couple of other people that had a bit of a problem trying to choose who they were going to pick [to save in the dilemma story]." She elaborated that she had listened to others' opinions but she also had made sure that,"…[my voice] was heard by the whole class!" With a smile she added, "…my voice was heard!…I got really loud and yelled….the person I got angry at…did hear!" She was referring to the heated discussion she had had with David who had insisted that in the case of their dilemma story (*The Reproduction Dilemma*) it was okay to not save a particular person. At the time of the interview, Simone was apparently still coming to terms with David's argumentation. She reported that she had been thinking about this for quite some time, "…just saving one life would mean only one instead of maybe possibly two or three…That's the only way I can think about it otherwise I don't get it." This seems to indicate that she continued trying to understand Dan's opinion that seemed to stand in stark contrast to her own and that she was still trying to find an explanation for herself.

Summarising, we can say that students reported that they felt their voices were heard and their opinions accepted. All interviewees seemed to appreciate the opportunity to hear about other people's thoughts and opinions and indicated the importance of knowing what others think and feel in order to care. These results confirm the quantitative results where over three-quarters (85%) of students indicated that they had communicated empathically with other students during the dilemma story activities, being open to and respectful of other students' opinions, and relating to other students' feelings. A small number of students were unsure, with only two disagreeing.

Critical Self-Reflection and Critical Thinking

When forced to make a decision students seem to engage in both critical self reflection and critical thinking (Settelmaier, 2009). Critical self reflection occurs when a student reflects on his/her own values in order to solve a problem. Critical thinking, on the other hand, is well documented in the literature as an analytic, systematic problem-solving approach that builds largely on existing knowledge. We asked students how they went about 'decision-making' in a dilemma situation, what processes they engaged in, what values/guidelines (if any) they were drawing on when coming to a conclusion. Some interviewees reported that they did not question their own views or become clearer about what was important to them, whilst others, like Sam, stated that, "…even though we aren't as pressured as being in the real situation, we kind of simulate in our minds from past experiences when we have been under pressure, we've had to make a really tough decision, we can put that together and think about that situation as though we were in that actual position and how we'd assess it." He described well the 'constructivist values-learning process' whereby students draw on previous experiences to find a solution first before constructing new knowledge by adapting and merging old and new knowledge in order to respond to a new situation. Sam's statement was confirmed by Steve who explained that for him the dilemma learning experience had, "…made me think about my own priorities about certain situations and things like that." And Jack argued along a similar train of thought when he said, "…it made me think about the way I [would] go about it all. During the interviews Julia, the research assistant, uncovered an interesting and somewhat unexpected aspect of 'values education' in Australian secondary schools: some students had stated that they did not change or reconsider their values through the dilemma story learning experience, however, further questioning revealed that some of these students were struggling with the concept of 'value', that is, they had no clear concept of the meaning of 'value'. This does not mean they did not have any values, only that they did not know what could be regarded as a value and thus they seemed unaware of the values they were basing their decisions on. A brief excerpt from an interview with Dan illustrates the issue well.

Julia, "Did it make you look at your values a bit more and make you think about it? Dan, "No…well, what do you mean by values?". Julia continued to explain the basic meaning of the term value, when Dan replied, "Well, when you put it that way, yes I did!"

Individual decision-making that involved critical self-reflection was experienced as difficult, challenging and sometimes confronting, as Nicky explained, "…decision making was difficult because we had to state reasons why…". Students had been asked during each of the dilemma question breaks to reflect individually at first before discussing their own ideas with others which apparently pushed some students out of their comfort zone, and some apparently did not like that very much, particularly Evelyn, "…I didn't really like the fact that I had to choose between who I'm going to save first…like messing with people's lives and sort of playing God, so I really didn't like it. I'd like it if I didn't have to make decisions!" Most interviewees, however, agreed that the dilemma-based values learning approach was preparing them for future decision-making, as Lee outlined, "…making decisions…[is] a very useful skill later on." And Emma added that whilst it was, "… frustrating when we had to choose…kind of confronting… I thought it was pretty good and [I] learned that decision making is not always going to be easy. I thought it was good!".

In relation to critical thinking, students reported that they were able to apply their existing knowledge when assessing the dilemma situation. The dilemma approach seemed to help Peta recognise the connection between real-life and science learning, "…it really did help us apply what we have learned in science." Students use their knowledge to critically assess a variety of possible solutions with a view to finding the most viable one.

Summarising, we can say that decision-making was experienced by many students as difficult, challenging and sometimes confronting – pushing some students out of their comfort zone. Some students reported that they did not question their own views and/or become clearer about what was important to them. However, further questioning revealed that some students seemed to be struggling with the basic understanding of the concept of value. Most students seemed to agree that the dilemma-based values learning approach was preparing them for future decision-making. These results were confirmed by the quantitative analysis where three-quarters (75%) of students indicated that the dilemma story learning experience had engaged them in reflecting critically on their own ideas, questioning their own views and becoming clearer about them. A small minority of students was unsure, while only 3 disagreed.

The Relationship between Science, Dilemma Pedagogy and 'Real Life'

We asked students about how they experienced the connection of the dilemma learning experience with science and 'real life'. In other words, could students see a connection between this approach, science and their lives outside of the science classroom? Generally, students seemed able to identify direct connections between the dilemma-based values learning approach and science. They appeared to appreciate the different approach and the opportunity to see how science can be applied in daily life. As Leah reported, "…science helps me… shape my values." And she added that, "… it is good to learn about how stuff works, and [that] there is more to it than just looking at it." Evelyn confirmed Leah's views by saying that, "… yes, [the dilemma learning experience connected well with science] 'cause science is very much...like… it can be problem solving as well as the very basic elements and that sort of thing!" Sam seemed to support Evelyn's and Leah's views by saying, "…I think it had a good connection with science. We thought about it and looked in more depth…we could use our morals and compare it with science." Emma stressed that, "…without science we kinda don't know as much about the world…..how things work, how things communicate with each other and how they work together and what goes with what and what doesn't go with what… then we really get an understanding of ourselves and the way we perceive the world in kind of a more open way." Emma's view seemed to be supported by Lee who seemed to think that, "… science really helps us be open about things. Basically, it had a good connection with science." For Peta the dilemma approach seemed to help clarify the connection between real-life and science learning, "…it really did help us apply what we have learned in science." Yet as Chloe explained, "… it kinda didn't feel like science! … well, it helped me apply it to the real life situation….because the stuff that we learn for school we want it to be relevant to what we want to do or to real life instead of just being work that we're never going to use again!" Chloe's statement about the importance of relevance of students' science learning to real life summarises well the statements of most interviewees. Interestingly she stated that it didn't feel like science maybe indicating that maybe her usual science learning experience lacks this aspect of real life connection or maybe indicating a discrepancy between the way, science is usually being taught to her.

Summarising, we can say that the students seemed to see a clear connection between the dilemma learning experience and science learning through connecting science content to the 'real world'. These results are confirmed by the quantitative analysis where just over three-quarters (77%) of the students indicated that dilemma story learning had helped them become critically aware about the misuse of science, and to learn that misuse or ignorance can have harmful long-term effects on their lives. A small proportion was unsure, while a small number disagreed.

Students' and Teachers' Views - Some Emergent Discrepancies

Almost all students – this includes Year 12 students - seemed to regard SRS as useful and expressed the wish that SRS should be done more often due to its direct relationship to real life. Jeremy, one of the male teachers, however, seemed more concerned about the 'crowdedness of the curriculum' and said it was "…easier to fit ethical dilemma stories into lower school classes rather than upper school classes". He seemed to consider this to be particularly the case for classes in which university aspirations were low. In other words, SRS could be taught to the less capable students whilst he seemed to think that it would not be as useful for the more academic students. Interestingly it was one of his high ability students who spoke out most strongly in favour of the SRS approach – she and another high achiever from Ron's class both seemed to be clear that this type of learning connected science to the 'real world' and confronted them with 'real life' problems where they could apply their scientific knowledge. It appears that Ron and Jeremy viewed SRS primarily as a 'motivation tool' whilst the female teachers stressed they would not be teaching the full curriculum if values were not also taught in the classroom. Delia and June seemed to view ethical dilemma stories as a useful pedagogical strategy to overcome the apparent science-values dichotomy. It was interesting to note that the interviewed students of the male teachers emphasised how much they appreciated the different style of the dilemma lessons, and that their teachers were trying something new even though they appeared uncomfortable. Comparing the opinions of the male teachers and the female teachers in the study, it was interesting to note that the female teachers seemed to assume an inherent connection between science and values thus making it indispensable to teach values as part of science, whilst their two male counterparts seemed much more concerned to cover as much of the prescribed content as possible. It is also interesting that the female teachers' views seem to support and be supported by the majority of the students' views.

CONCLUSIONS

The results of our study indicate that a large majority of students across the sample engaged positively in a socially responsible science classroom learning environment that afforded development of critical scientific literacy skills. In particular, they (a) experienced the dilemma stories as engaging and authentic and as connecting science learning with 'real life' problems, thus making their scientific knowledge applicable; (b) had positive perceptions of their participation in dilemma learning activities which, for some of their teachers, meant an entirely new teaching style whilst, for others, it seemed to have been more of an extension of their usual teaching style; (c) perceived that their teachers had allowed them to express their opinions and 'talk to each other during class'; (d) had engaged empathically with other students in collaborative decision-making, even though sometimes this was not easy due to lack of conflict resolution skills; and (e) had reflected critically on their own ideas and values and found that the learning experience had helped them to become critically aware of the use/applicability of scientific knowledge. Only a small minority of students consistently disagreed that they had experienced any of these aspects of the classroom learning environment. Second, the dilemma teaching approach was implemented inconsistently by teachers. The 2 female teachers closely enacted the role of dilemma learning facilitators whereas the 2 male teachers reverted to more traditional didactic teaching methods. It is interesting that, although the largely positive attitudes of most students and of the female science teachers stand in contrast to the less than favourable attitudes of the two male science teachers, the latter expressed surprise at how well dilemma teaching had worked in their classrooms, especially the positive engagement of their students. These results are consistent with our earlier research (Settelmaier, 2009) and add further evidence to the claim that a socially responsible science education based on ethical dilemma story pedagogy offers a promising means to develop critical scientific literacy skills with which students can engage as socially responsible citizens in informed decision-making about the appropriate use of science for addressing global issues such as climate change and environmental sustainability.

The results suggest that if this type of values learning is to be more widely integrated into science classrooms of the future then transformative professional development is needed that engages teachers in reflecting critically on their (hidden) assumptions about what constitutes legitimate science education and what does not; in particular, on the science-values dichotomy. Because many pre-service science teachers are likely to regard values learning as 'not really' science education, 'value-added' reform of science teacher education programs is needed. Such an approach would emphasise the importance of integrating values learning into the science curriculum, not as a luxury that may be afforded if there is sufficient time available but rather as a vital necessity if the decision-makers of the future are to learn necessary skills for preventing the world from repeating the environmental disasters of the past. Science teachers have a pivotal role in this essential educational process. Another promising approach to integration that we are investigating with our current research is via inter-disciplinary teaching in which science teachers collaborate with teachers of other subjects (e.g., languages, mathematics, society & environment) to develop and teach ethical dilemma stories, including students in learning to write their own stories.

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USA FOURTH GRADE STUDENTS' BELIEFS ABOUT THE NATURE OF SCIENCE

Edward L. Shaw, Jr.

Department of Leadership and Teacher Education
University of South Alabama
Mobile, AL 36688

eshaw@usouthal.edu

Lynda Daughenbaugh

Department of Leadership and Teacher Education
University of South Alabama
Mobile, AL 36688

ldaughenbaugh@usouthal.edu

Ann K. Nauman

Professor Emeritus
Southeastern LA Univ.
Hammond, LA 70402

ABSTRACT

This study focused on 4th grade students' perceptions of the Nature of Science. Students were asked to draw and label concept maps about their knowledge and perception of science. They were interviewed to explain their maps. Analysis revealed an equal number of nodes drawn by both male and female students. However, female students used a greater variety of colors to construct their maps. Students were asked to respond to 11 questions developed by the researchers. Data gathered showed students chose science as a favorite subject, were interested in science careers, and perceived science as important. However, students had difficulty naming a scientist, identifying uses of science in everyday life, and designating scientific inventions. School, parents, and television were identified as their main sources of scientific learning. Results suggested science was being taught as abstract textbook concepts with few connections made to real world experiences, and limited time spent teaching about important scientists and inventors. Researchers recommend trade books dealing with science topics, biographies of scientists, and hands-on activities be given a greater emphasis in science teaching and learning in the elementary school.

Keywords: *science education standards, nature of science, concept maps, mind maps*

INTRODUCTION

The Nature of Science (NOS) has been described as the values and beliefs of scientific knowledge and development (Lederman, 1992). Research has provided many definitions, meanings, and interpretations regarding the NOS such as using science to solve everyday problems which involve both scientific content and processes. According to Bell (2008), "using science in our everyday lives requires understanding the nature of science" (p. 1). Although no single universal step-by-step scientific method captures the complexity of doing science, a number of shared values and perspectives characterize a scientific approach to understanding nature. The National Science Teachers Association (NSTA) states the following concepts are important to understanding the Nature of Science (NOS): scientific knowledge is simultaneously reliable and tentative, and testable against the natural world; creativity is a vital, yet personal, ingredient in the production of scientific knowledge; science is limited to naturalistic methods and explanations and; a primary goal of science is the formation of theories and laws. Further, contributions to science can be made, and have been made by people throughout the world. The scientific questions asked, the observations made, and the conclusions reached in science are to some extent influenced by the existing state of scientific knowledge, the social and cultural context of the researcher, and the observer's experiences and expectations. The history of science reveals both evolutionary and revolutionary changes. With new evidence and interpretation, old ideas are replaced or supplemented by newer ones. While science and technology do impact each other, basic scientific research is not directly concerned with practical outcomes, but rather with gaining an understanding of the natural world for its own sake.

Bell also stated that teaching students about the Nature of Science (NOS) helped students view science as a dynamic process. Additionally, it helped them develop richer understandings of physical science, increased their interest in studying science, showed them the human side of science, and provided them with accurate views of the scientific enterprise. Teaching the NOS begins the process of producing scientifically literate citizens. Benchmarks for Science Literacy (AAAS, 1993) and the National Science Education Standards (NRC, 1996) advocate students should possess adequate mastery of the NOS. Lederman and Lederman (2004) listed seven aspects of the NOS relevant to K-12 students' lives. These aspects involve an understanding that scientific knowledge is tentative, subjective, partially based on human inference, empirically- based, socially and culturally embedded, and dependent upon human imagination and creativity.

Concept mapping, as a tool to visualize and communicate conceptual understanding, has been extensively studied in the context of science education. According to Rye (1995), concept mapping is especially suited for science because it can support learners in their thinking about relationships between concepts. Variations on concept mapping such as Mind Mapping®, which include the elements of color and symbols, are less evident in the literature, but provide relevant possibilities for applications in content domains such as art education, as well as, science education.

A concept map is a graphical representation of a domain of knowledge consisting of nodes representing concepts, objects, or events connected by directional links that describe the relationships among and between the nodes. Concepts are arranged so that the most general concepts appear at the top or middle of the concept map, with less inclusive and more specific concepts emerging below or around (Novak, 1977, 1978, 1998, 2004). An exploration of the international literature reveals Mind Mapping® as a teaching and learning method that emphasizes visual representation and offers a variation of concept mapping. This method was developed by Tony Buzan (2006) and integrates the use of color, symbols, or pictures with the words. The creation of concept maps may also be facilitated with the use of mapping software such as Inspiration® that allows learners to create a concept map using the various symbols and features of the program.

The *Atlas of Science Literacy* (2001) states that "Project 2061 is a long-term effort to improve education for all citizens to attain science literacy-that is, a basic understanding of the natural and social sciences, mathematics, and technology, and their interactions"(p. 3). Project 2061's *Science for All Americans* (1900) and *Benchmarks for Science Literacy* (1993) proposed standards for each grade level (See Appendix A) in areas such as Nature of Science, Nature of Mathematics, Nature of Technology, Physical Setting, and The Living Environment. Most states were encouraged to incorporate Project 2061 standards into their science standards. The researchers sampled science programs of several states that were representative of each region of the continental United States to examine in terms of their inclusion of the standards suggested by Project 2061.

Research Questions

This study focused on investigating some of the content and aspects of the Nature of Science as understood by fourth grade students. Students were asked to respond orally in an interview format, and to visually represent via concept maps some of the science content they had been taught. The research questions were: What are fourth grade students' perceptions of the Nature of Science?; What science concepts and information are fourth grade students able to articulate?; and, are there any differences in attitudes towards science expressed in terms of gender?

Participants

Participants in this study were 12 fourth grade students in a self-contained, public, elementary school in southwest Alabama in the United States. There were eight girls and four boys. One of the boys was identified as a gifted student and participated in the gifted program provided by the local school system. All of the students were Caucasian and eleven of the twelve were born in the United States. One girl was born in Russia and adopted by an American family. All participants were either nine or ten years of age, and were from middle to low socioeconomic groups.

METHODS

The classroom teacher used concept maps and Venn diagrams as part of her science instruction in the unit taught before the researchers collected data. As a follow up to the teacher's instruction, the researchers conducted a whole class activity in which all the students constructed a concept map representing their individual families. This was used as a review to ensure students understood how to construct a concept map and were able to focus on the content during the actual data collection. To complete this task, each student was provided a 42.9 x 27.8 cm piece of paper and a pack of 10 felt tip markers of assorted colors. The students were instructed to write the word "science" in the center of their paper and then draw everything they could think of to describe science. They were given 20 minutes to complete their concept/mind map.

After completing their maps, the researchers interviewed twelve of the students whose parents signed a permission slip. Not all parents of the children in the class were agreeable to the interview process because of their concerns about their child being audio or videotaped. The classroom teacher explained in the letter asking for permission for their child to participate in the research that the audio or videotapes would be destroyed after being transcribed. Some parents were worried about their child's audio or video interview being played in front of an audience, or posted to the Internet.

These twelve students were asked to interpret their concept map in reference to the individual symbols, pictures, and words they placed on their concept map. The researchers also inquired about the source of the students' learning of the various concepts. In the second part of the interview the following 11 questions were asked: What is your definition of science; tell me something you know about science; how do we use science in our everyday lives; where have you learned science; do you like science as a subject in school, why or why not; is science important, why or why not; what do scientists do; can you name a scientist; do you think you would like to work in a science field, why or why not; and, do you think it is easier for boys or girls to learn science, why or why not?

RESULTS

Each concept/mind map was analyzed in terms of demographic information, (school, grade, ethnicity, and age,) as well as quantitative data (number of nodes, levels, symbols, and colors generated). (See Table 2) Triangulation, "a validity procedure where researchers search for convergence among multiple and different sources of information to form themes or categories in a study" (Creswell & Miller, 2000, p.126), was pursued as multiple researchers engaged in the data analysis.

The *nodes* were counted in each drawing. A node is a concept/idea, or sub-concept/idea; the *level* indicated how many layers of concepts came from the original concept representing the levels of the hierarchy; the *symbol* was anything drawn to represent a concept; and *color* represents how many different colors were used in the visual representation. (Example: plant>leaves> smooth. This would be three nodes, three layers, no symbols, and one color.) Number of nodes, levels, symbols, and colors, were calculated by multiple researchers for reliability. (See Table 1)

The number of nodes identified in the maps by females in the first through fourth levels appears greater than the males. In levels six and seven the males appear to have identified more nodes than the females, although the number of nodes identified is minimal. The number of colors used by the females was more than the colors used by the males. The number of females and the number of pictures drawn by females was more than drawn by the males.

Table 1 Number of nodes from concept/mind map

	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	# of colors	# of pictures
Boy 1	6	13	9	4	3	1	6	0
Boy 2	6	26	0	0	0	0	6	5
Boy 3	7	14	3	0	0	0	1	2
Boy 4	4	6	3	1	0	0	11	0
Girl 1	6	2	2	1	0	0	2	3
Girl 2	11	4	4	1	0	0	10	0
Girl 3	7	24	0	0	0	0	11	2
Girl 4	8	15	3	0	0	0	8	3
Girl 5	4	11	0	0	0	0	5	0
Girl 6	9	10	6	1	0	0	10	4
Girl 7	10	5	0	0	0	0	11	0
Girl 8	4	4	3	2	0	0	6	4

The science concepts represented by the students' drawings on their concept maps were analyzed and classified by a panel of professors from the elementary methods faculty of the researchers' University to determine which standard the concept would fall within, based on Project 2061's suggested areas. The panel was unanimous in their findings. It was noted by the panel that not all of Project 2061's areas of standards were represented on the students' concept maps. In fact, the science concepts identified by the panel was limited to four areas: Nature of Science, Nature of Mathematics, Physical Setting, and The Living Environment. (See Table 2)

Table 2 Summary of 4th Grade Science Content Standards Found On Concept Maps

Student	Nature of Science	Nature of Mathematics	Physical Setting	The Living Environment
Dylan 10	1		12	8
Russ	2		2	
Dylan 11	1		1	
Lauren	1		2	
Tatiana	1		1	3
Tessa	2		11	
Emily	4		11	2
Madison	2		3	4
Patricia	2	1	3	1
Austin	1		6	1

Responses to the 11 questions were tallied and analyzed for emerging themes. Some of the questions appeared to yield differences in attitudes by gender, although most did not. Some questions were more difficult for the students to answer than others. However, the researchers found that most of the students' answers were reflective of their recent science unit of instruction on astronomy.

When asked about the definition of science, the male students stated that there were particular areas of science that are important to know about like planets, and space. Further, they stated that science was their favorite subject and it helps people learn about the earth and things in it. The female students said that science helps teach about nature, the world, and projects. However, several girls replied that they were not sure, or didn't know how to define science.

Boys named the four states of matter, the animal kingdom, electrical energy, space, oceans, meteorologists, power, lights and constellations when asked what they knew about science. Girls listed astronauts, dinosaurs, rocks, fossils, using science to figure things out, the earth's revolution around the sun, how the sun makes food and energy, and being careful not to pollute the sky and earth. A couple of girls said they couldn't remember anything about science.

A question about how science is used in everyday life yielded few responses. The boys mentioned fire for welding, matter is in everything, astronauts study space, marine biologists study fish, electricity in lights and some said they didn't know. The girls listed electricity, water, paper made from trees, enjoying nature, things seen outside, plants, and being as "green" as possible. As before, a few girls said they don't know how science is used in everyday life.

Both male and female students struggled to name a scientific invention. The boys named the telescope and radio as scientific inventions. Some of the boys could not think of an answer. The girls identified electricity and water as scientific inventions. However, several of the girls could not respond to the question.

Where science was learned by the students resulted in a variety of answers. The boys mentioned textbooks, their fathers, television, and church. The girls gave credit to learning science from school, parents, their mothers, television, walking outside, and textbooks. According to the boys and girls, watching nature and science-oriented programs on cable channels was a good way to learn about science.

The majority of both boys and girls stated that they liked to study science as a subject at school. All of the boys gave a positive response. With the exception of two girls who answered negatively, the girls had a positive attitude toward studying science as well.

All the male students agreed that science is important. The female students, however, gave mixed responses. Five of the female students agreed with the male students that science is important, but two of them said no, science is not important, and two other female students said they were not sure if science is important or not.

Describing what scientists do resulted in a diverse list from both male and female students. The males responded by saying that scientists do research, look for deeper and deeper meanings, show how things are related to each other, and study the earth, planets, and rocks. One of the boys said he didn't know and another boy did not respond at all. The females listed making inventions, studying rocks, finding out where dinosaurs lived, figuring out ways we can use things, researching, and finding out what happened to people and why as work conducted by scientists. As with the male students, one female student did not respond to this question.

Asking the students to name a scientist was possibly the most difficult question posed by the researchers. Two of the male students were able to respond and two were not. Similarly, two of the female students were able to name a scientist, and six were not. The scientists specified by the students were Albert Einstein and Werner von Braun. Naming these particular scientists may have been directly related to their recent unit of study on astronomy.

Working in a science field was seen as a positive career choice by three of the boys. However, one of the boys stated that he was not sure if he would like to have a career in science or not. The female students were also divided in their opinions about choosing a science-related career path. Four of the girls said yes they would like to work in a science field, one said definitely no she would not, and three said they were not sure.

Three of the boys and two of the girls felt learning science was easier for boys to learn than girls. One boy felt it was easier for boys to learn science than girls because of the gross things involved in learning science like dissecting frogs. Two of the girls said no, it is not easier for boys to learn science than girls. Interestingly, one boy and four girls stated it was of equal difficulty for both sexes. These students' answers may have been influenced by the fact that their science teacher is a female.

DISCUSSION

The results of the study were limited by the small sample size used and therefore, generalizations to other fourth grade classrooms are extremely limited. The population was confined to one fourth grade classroom from which twelve children's concept maps were analyzed and they were later interviewed. The small sample number was a consequence of not being able to interview all of the subjects who had participated in the construction of concept maps due to not being able to gain permission for the audio or videotaped interviews. While parents did not object to the concept maps, many were wary of their children being audio or videotaped. Any follow-up research should be done in multiple grades, schools, regions of a country, and various countries. The following is a discussion of the results as they relate to the research questions.

The beliefs about the Nature of Science (NOS) of these fourth grade students were examined through the construction of concept/mind maps and a follow-up interview. The data were collected from the analysis of their concept maps and the answers given to 11 interview questions devised by the researchers. This study was conducted late in the school year after the majority of their standardized testing had occurred. Some of the responses provided by the subjects were probably influenced by what they were currently studying or had just completed. The teaching of science may have been neglected due to the review for, and administration of, the high-stakes standardized tests which emphasize reading and math skills.

Upon analysis of the interview questions it was apparent that the children reported science as one of their favorite subjects, they were interested in science careers, and perceived science as important in everyday life. With the exception of a couple of students, the subjects were unable to name a scientist, identify uses of science in everyday life, and list inventions made by scientists.

Males identified science concepts such as the states of matter, the animal kingdom, electrical energy, space, oceans, meteorologists, power, lights and constellations when asked what they knew about science. Male students viewed the NOS as an exploration of science concepts and processes, such as space, matter, and electricity. One male student said “Fire is plasma. Say if you are a welder, like my father, you heat the gases until they become the fourth stage of matter, plasma. Basically your body is matter and you couldn’t be who you are without matter.” He relates a science concept studied in school to his everyday life, his father’s career. Males said that scientists explore both concrete and abstract concepts with no mention of the practicality of their discoveries. One male stated “Scientists create things, they research and depending on what type of scientist they are, they research a topic and like I did with concept map, they get deeper and deeper and branch off and relate.” The boys appeared to be more interested in science as a means to explore both concrete and abstract concepts, such as space and forms of matter. One boy stated the reason he was interested in science was “because I can’t just memorize like say history, like history, but with history you memorize dates for the test and me I like science because you can get deeper and deeper with your information.” The researchers then asked him if he felt history is limited. He responded “History is limited because it is hard to relate to and there was only so much of it that was recorded.”

Females listed astronauts, dinosaurs, rocks, fossils, using science to figure things out, the Earth’s revolution around the sun, how the sun makes food and energy, and being careful not to pollute the sky and earth. The students had just completed a unit dealing with astronomy which may have influenced their identification of those particular science concepts. Two girls said they couldn’t remember anything about science. The female students in this study stated that the NOS involved practical applications of science for animals and the ecology of the planet. One female stated “Science helps figure out ways we can use things and ways we can figure things out and use it.” Another girl said “It helps you learn about projects and everything to do with the outside world.” The girls appeared to be interested in science that deals with inventions and practical applications like helping animals and the preservation of the earth like solving problems such as providing clean air and water.

The differences between the views of males and females in this study may indicate that the sexes may have a different orientation towards the learning of science, the uses of sciences, and the investigation of science. If these findings occurred again in multiple studies with larger populations, multiple grade levels, and in different countries, the implications for teachers, textbook suppliers, and test makers would be very significant.

Three of the boys and two of the girls felt learning science was easier for boys to learn than girls. One boy “felt it was easier for boys to learn science than girls because of the gross things like dissecting frogs” while a girl said “boys, because boys are more astronauts than girls.” Another boy said “Since I am a guy, it is easier for the guys.” Interestingly, one boy and four girls stated it was of equal difficulty for both sexes. One female stated “because they are both being taught they can learn the same amount so it is hard for both.” One factor of this study to consider is that their science teacher is a female, all of the previous grade level teachers were female, and some of the children may be influenced by traditional roles for males and females as experienced in their family settings.

The children’s inability to identify science concepts, scientists, everyday uses and inventions of science, and the relationship between science, mathematics, and technology may have been influenced by the science curriculum adopted by the state and public school district. Although science is supposed to be taught everyday in every grade level, due to the importance placed on standardized testing which emphasizes reading and math skills, science may not be taught as often or as thoroughly as other subjects.

Project 2061 identifies many standards for science that should be emphasized in each grade level, including the Nature of Science, Mathematics, and Technology. Although a program called the Alabama Math, Science, and Technology Initiative (AMSTI) is supposed to be implemented state wide, budget cuts and high-stakes testing have limited AMSTI's success. Many states have standards specified for science, but a selection of science programs from states in different parts of the United States indicates science instruction is limited to the following four areas for most states: Nature of Science, Nature of Mathematics, Physical Setting, and the Living Environment. Of the states randomly selected, three explicitly stated standards for learning about the Nature of Science, one state program identified standards for learning about the Nature of Mathematics, and one state listed standards for learning about the Nature of Technology. However, all the state programs reviewed by the researchers had standards for teaching about the Physical Setting and the Living Environment.

Akerson, Buzzelli, and Donnelly (2010) stated that "it is critical that teachers have adequate views of NOS and explicitly teach NOS. Pre-service teachers can improve their NOS conceptions by participating in science methods courses that explicitly emphasize NOS" (p. 213). Therefore, it is suggested that this standard be taught overtly in the classroom at every grade level in order to attain mastery and retention of knowledge about the Nature of Science. Sometimes the science curriculum can negatively impact the teaching of science as well as the retention of the science concepts for immediate and delayed testing. Akerson, Buzzelli, and Donnelly (2010) stated that "The main factors that hindered or facilitated teaching NOS for preservice teachers were the influence of the cooperating teacher and the use of the science curriculum" (p. 213). It is also suggested that science by taught using an inquiry, hands-on approach with real world connections to the lessons and concepts. This would move science from an abstract, textbook driven curriculum to one in which students learn through a constructivist approach to teaching while seeing an everyday relevance of science to their lives. The researchers recommend that the teacher involved in this research study incorporate science trade books written for children such as biographies of current and historic scientists and other nonfiction works, and appropriate technology into their science instruction to enhance the teaching and learning of abstract science concepts, and to encourage the interest of both genders in future science courses and careers. This may be a helpful suggestion for elementary schools that have large literacy and mathematics blocks with limited time allotted for science.

Future research on this topic might include surveying additional classrooms of the same grade level, different schools with diverse student attributes, and possibly sampling all elementary grade levels. Additionally, reviewing additional state science curriculums may reveal which standards, concepts, processes, and dispositions are actually being taught due to the impact of knowledge about the Nature of Science, high-stakes testing, the local science curriculum, and/or training of the classroom teacher.

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Appendix A

Project 2061's Fourth Grade Content Standards

1. The Nature of Science
A. The Scientific World View, Scientific Inquiry, and The Scientific Enterprise
2. The Nature of Mathematics
A. Patterns and Relationships, Mathematics, Science, and Technology, and Mathematical Inquiry
3. The Nature of Technology
A. Technology and Science, Design and Systems, and Issues In Technology
4. The Physical Setting
A. The Universe, The Earth, Processes That Shape The Earth, Structure of Matter, Energy Transformation, Motion , and Forces of Nature
5. The Living Environment
A. Diversity of Life, Heredity, Cells, Interdependence of Life, Flow of Matter and Energy, and Evolution of Life

Various States Fourth Grade Standards

Alabama's (SE United States)
1. Describe how electrical circuits can be used.
2. Compare different pitches of sound.
3. Recognize how light interacts with transparent, translucent, and opaque materials.
4. Describe effects of friction on moving objects.
5. Describe the interdependence of plants and animals.
6. Classify animals as vertebrates or invertebrates and as endotherms and ectotherms.
7. Describe geological features on Earth.
8. Identify technological advances and other benefits of space exploration.
9. Describe the appearance and movement of Earth and its moon.

Oklahoma's (Southern part of Midwest United States)
1. Observe and Measure
2. Classify
3. Experiment
4. Interpret and Communicate
5. Inquiry
6. Position and Motion of Objects
7. Electrify
8. Characteristics of Organisms
9. Properties of Earth Materials

California's (West Coast of United States)
1. Electricity and Magnetism
2. All organisms need energy and matter to live and grow.
3. Living organisms depend on one another and on their environment for survival.
4. The properties of rocks and minerals reflect the processes that formed them.
5. Waves, wind, water, and ice shapes and reshape Earth's land surface.
6. Scientific meaning

Washington’s (NW United States)
1. Measurement of Force and Motion
2. States of Matter
3. Heat, Light, Sound, and Electricity
4. Earth in Space
5. Formation of Earth Materials
6. Focus on Fossils
7. Structures and Behaviors
8. Food Webs
9. Heredity and Adaption

Connecticut’s (NE United States)
1. Forces and Motion
2. Matter and Energy in Ecosystems
3. Energy in the Earth's Systems 4. Science and Technology in Society

Indiana’s (Midwest United States)
1. Collaboratively carry out investigations
2. Skills and techniques to answer questions and solve problems
3. Investigate changes of the Earth and sky.
4. Increasing knowledge of the variety of organisms
5. Apply mathematics in scientific contexts.

EXPLORING THE EFFECTS OF DEVELOPING COLLABORATION IN A PRIMARY SCIENCE TEACHER COMMUNITY

Martin Krabbe Sillasen

VIA University College
&
Department of Education, Learning and Philosophy
Aalborg University, Denmark

msil@viauc.dk

ABSTRACT

This paper presents findings from a qualitative study to explore factors that may facilitate sustainable changes of collaboration in a primary science teacher community in one school. The context for this study is a development project aimed at improving science teaching by changing teacher's collective work in schools and developing network between schools. The objective is to improve the collaboration within primary science teacher communities on sharing best practice and developing new ways of teaching. This study represents an in-depth approach to explore possibilities and constraints for how a development project can facilitate sustainable change in primary science teachers' collaboration.

The purpose of the research project introduced here is to examine closer, why many development projects fail to produce sustainable results. The framework of McLaughlin and Talbert (2006) on *Building teacher learning communities* is introduced to investigate factors that may facilitate sustainable changes of the collective work in science teacher communities. Examples on how McLaughlin and Talbert's analytical framework is used as a diagnostic tool are presented. Such an analysis provides a vantage point for researchers to outline potentials and constraints in a schools effort to transform the culture of the primary science teacher community.

Keywords: *Teachers professional development, Teacher practice, Developing science teacher communities.*

INTRODUCTION

In the Danish primary and secondary school system the collaboration between science teachers is characterized by practical issues, e.g. maintaining laboratories and teaching materials. These tasks are well organized in most Danish schools (Andersen, 2006). But research has shown that primary science teachers lack the opportunity to engage in collaborative processes, where focus is sharing best practice and development of new ways of teaching (Abell & Lederman, 2007; Sørensen, Horn, & Dragsted, 2005). This means, that the prevailing culture in many schools is one of individualism and lack of collaborative processes about pedagogical innovation.

Within a Danish context it has been suggested, that to achieve and maintain a high level of quality in science teaching, it is necessary to develop the collaboration in science teacher communities. This collaboration should focus on sharing best practice, norms, values and collaborating about new ways of teaching (Andersen, 2006; Sølberg, 2007).

EVIDENCE OF THE EFFECT OF DEVELOPING TEACHER COMMUNITIES

Developing teacher communities in schools align with empirical evidence of the most effective strategies of teacher professional development. Statistical studies aimed at, among other, estimating the effect of professional community on student outcomes support the hypothesis that students do better in schools where teachers take collective responsibility for the success of all students. They also provide evidence that students' socioeconomic background had less effect on their outcome of education if their teachers were engaged in collaborative teacher environments (Lee & Smith, 1996; Lee, Smith, & Croninger, 1997). In their large-scale study conducted in England, Bolam et al. compared professional learning community characteristics with student outcome from a national pupil assessment database. They found that there was a statistically significant relationship between student outcome in schools where developing and planning curriculum activities is collective work in a teacher community (Bolam et al., 2005). In another study researcher's found evidence that students performed better in schools where teachers collaborated to develop and assess teaching interventions (McLaughlin & Talbert, 2006). A national survey in Denmark supports this evidence (Mehlbye & Ringsmose, 2004). They identified several factors that characterized high performing schools, e.g. a collaborative teacher community; leadership that involves the teacher community in decision processes; an organization within the school where division of responsibilities are well structured; and a school that is open to new innovations.

These empirical data provide evidence that developing teacher communities in schools can generate improvements in teachers' performance which in the end has a positive effect on the student outcome.

DEVELOPING SUSTAINABLE TEACHER COMMUNITIES

The development of teacher communities can influence teachers' motivation; provide extra resources for teaching; create spaces for sharing best practice; and increase reflexivity on pedagogical issues among teachers in the community. This can prompt change in the way that science teachers teach and think about teaching science. However, many development projects focusing on changing teachers' attitudes and work routines fail to succeed these objectives. Teachers involved in change processes often revert to their former work routines as the development project ends, and resources and the external pressure within the development projects stops (Fullan, 2007). But what characterizes a development process that can generate sustainable changes within a teacher community?

I have adapted McLaughlin & Talbert's framework (2006) on *building school-based teacher learning communities* to investigate factors that may facilitate sustainable changes of the local science culture in a primary science teacher community.

The results presented in this paper are based on a qualitative study of developing a primary science teacher community in one school. The objective of the development project is to provide better opportunities for primary science teachers in schools to collaborate about curriculum development and new ways of teaching.

THE NATEKU-PROJECT

The context for the research presented here is a development project co-funded by the Ministry of Education in Denmark and 4 municipalities with a budget of approximately

800.000 Euros. The development project, called the NaTeKu-project, is a 3-year project that was initiated in 2007. The NaTeKu-project involves 80 primary science teachers in 20 schools in 4 municipalities. The primary objective is to develop collaborative processes in primary science teacher communities in the participating schools to facilitate sustainable change of the collective work. The secondary objective is to develop scaffolding structures in each municipality that can support networking between teachers from different schools. Networking provides opportunities for teachers to compare different models of collaboration and to share knowledge about curriculum development. Stakeholders in this process are the municipalities, local science centers and science coordinators associated to each municipality.

The managing body of the NaTeKu-project is the House of Science (www.naturvidenskaberneshus.dk) which is part of the National Center for Education in Science, Technology and Health-science (www.nts-centeret.net).

Project-managers from the House of Science support the scaffolding process in each municipality as well as in each of the participating schools.

RESEARCH FOCUS

The scope of the research reported in this paper is not concerned with whole school development, but is limited to a study of a primary science teacher community in one particular school.

Researchers have been involved from the early stages of the NaTeKu-project. They will follow the developmental process and its impact on changing the collaboration in primary science communities in the participating schools as the project progresses.

This will provide the opportunity to investigate:

1. *What are the possibilities and constraints for developing the collaboration in primary science teacher communities?*
2. *How does the content of the collaborative work in a primary science teacher community make sense to individual science teachers own practice?*

THEORETICAL FRAMEWORK

McLaughlin & Talbert's notion of a *teacher learning community* is a shared space, where teachers work collaboratively to reflect on their practice, examine evidence about the relationship between practice and student outcome, and make changes that improve teaching and learning for the students in their classes (McLaughlin & Talbert, 2006). A teacher learning community is positioned at the "meso-level" between the "macro" or system-level and the "micro-level" of realities in the classroom. It represents a shared space where teachers can negotiate and interpret information from the larger educational system. In this sense the teacher learning community allows teachers to connect their work to larger system context.

A strong teacher learning community is one that focuses on improving practice, shared accountability, establishing ownership of the development process among most of the members of the community (McLaughlin & Talbert, 2006).

Their notion of building a teacher learning community resonates with the objectives of the NaTeKu-project as well as the previous discussion about sustainable collaboration in primary science teacher communities that focus on sharing best practice and developing new ways of teaching.

There is, however, a difference between developing primary science teacher communities in the NaTeKu-project, and building a teacher learning community as described by McLaughlin and Talbert. That is, none of the primary science teacher communities in the NaTeKu-project examines evidence about student outcome as a starting point for developing collaborative work. Their entry point is to analyze current collaborative efforts about planning curricula and teaching. The second step is to inquire and negotiate what elements of their collaborative work can be improved, and how they can improve it. The third step is then to realize initiatives and assess how they improved their collaboration at multiple levels in the community. During all three steps the municipalities organized network-meetings, where teachers shared knowledge with teachers from other schools participating in the project.

This model was a deliberate approach to allow different teacher communities to organize their own collective work within schools, and then to network with teachers from other schools to compare collective initiatives.

It is crucial to engage all teachers within a community in the process of designing the change initiatives, because if the change is to be sustainable, teachers need to develop ownership of the collaborative activities. Fullan argues that

> *…implementation and continuation [of change processes] are not just technical problems. Even the best technical ideas, in the absence of passion and commitment, do not go very far. … unless [teachers] are bound together by a moral commitment to growth, empathy, and shared responsibility, [they] are as likely to replicate the prevailing school culture as to change it.* (Fullan, 2007)

Following this argument it is important for the managing body of the developmental process to consider, how they can construct a scaffolding structure within the project to support stakeholders at all levels in their process towards the objectives of the developmental process.

In their model Mclaughlin and Talbert (2006, chp. 3) outlines three important factors that support the process of changing a school culture:

1. *Teacher learning community development, spread and sustenance depends on proactive leadership within and outside the school.*
   In the NaTeKu-project there are four levels of leadership, two outside and two inside the school. Outside the school the managing body of the project and municipal science coordinators collaborate on creating scaffolding structures that supports the developmental process on each school. Inside each school the principal and "community coordinators" play different roles in scaffolding the developmental process.
2. *A teacher community of practice develops through joint work on curriculum development and new ways of teaching.*
   The entry point into the change process can e.g. be a subject like primary science. That is the case of my research.
   In the following analysis of a primary science teacher community I present indicators of potentials and constraints for developing the collaboration between teachers.
3. *Teacher learning in a community depends on how well the collaboration is designed and guided*.

That is to say how well organized an effective learning environment is created for the teachers. The crucial point is how well activities are organized within the school, and what kind of scaffolding structures have been constructed to support networking between schools in the NaTeKu-project?

In their research McLaughlin and Talbert found that teacher learning communities move through a number of developmental stages to become strong, and that the transition between these stages depends on how a teacher learning community address challenges that relates to all three factors listed above (McLaughlin & Talbert, 2006).

In this study there are given examples on how McLaughlin and Talbert's analytical framework is used, as a diagnostic tool, to determine, how well the development process is implemented in a primary science teacher community. Such an analysis provides a vantage point for researchers to outline potentials and constraints in a schools effort to transform the culture of the primary science teacher community.

METHODOLOGY

In the qualitative studies in the NaTeKu-project, communities of primary science teachers in three schools were asked to participate. These schools were chosen on the basis of a quantitative survey that provided broad categories of answers to the research questions. This included information about the primary science teachers characteristic and attitudes about collaboration in different contexts as well as general trends of their teaching.

The major challenge in the qualitative research process was to build trustful relationships with the primary science teachers to collect information about their collaboration. First I observed a particular primary science teachers' daily work during 6-8 days. These observations allowed me to study the primary science teachers' relationships with other teachers in the primary science teacher community and their joint activity, actions, rituals, use of language and artifacts. These elements provided important inferential keys to the primary science teacher community under study (Miles & Huberman, 1994).

Based on observations I interviewed key-informants with-in and outside each primary science teacher community. In these interviews informants acted as co-interpreters of my previous observations of relationships, events, actions or use of artifacts. In this perspective, events that I, as an observer, and the informant, as an actor, participated in forms a common reference in the interview (Kvale, 2004).

SETTING THE SCENE

One of the schools in the qualitative study is chosen to illustrate how McLaughlin and Talberts' framework can be used as a diagnostic tool to determine the schools effort of changing the local scientific culture in their primary science teacher community. All names the following presentation are pseudonyms.

The school is situated in village in a rural district in the western part of Denmark. The population consists of many middle- and few low in-come families. In the village there are small and middle sized industries, where many local people are employed. In the rural district around the village there are many farms of various sizes.

There are 400 students in the school, ranging from grade 0 to grade 9.

The school employs about 35-40 teachers. They are organized in three departments related to different grade levels (Lower department: grade 0.-3., Middle department: grade 4.-6. And Upper department: grade 7.-9.). Each department has autonomy to make decisions about cross-curricular activities.

Primary science is taught from grade 1 to grade 6. There are some transitions of science teachers between the departments. This means that the primary science teacher community includes teachers from all three departments.

Two experienced science teachers' had the role as coordinators in developing the primary science teacher community in the NaTeKu-project. They organized activities and provided supervision for the other participants in the development process.

Peter is one of these coordinators. He usually teaches biology and physics in the upper department (grade 7.-9.). Peter does not teach primary science in the other departments. But he is one of the driving forces in the schools effort to develop a coherent scientific culture. The schools participation in the NaTeKu-project provided resources and a scaffolding structure to support this process. Peter is a key-player, because he acts both as a moderator of the joint activities in the primary science teacher community, as well as being a mediator of the dialogue about developing the science culture with the science teachers in the upper department.

Susanne is the other coordinator. She teaches primary science in both the lower department (grade 0.-3.) and the middle department (grade 4.-6.). She is recognized as a very competent primary science teacher in the community. Her colleagues talk about her creativity in developing new ways of teaching as well as challenging students on their communicative skills in science. She is also considered to be a teamplayer in collaborative situations. In these aspects she acts as a rolemodel for many of the other primary science teachers.

Peter and Susanne complement each other in their central position in the developmental project. Peter is more structured and able to keep focus on the objectives of the change process. Susanne is very good at challenging their usual work routines and come up with new ways of teaching or topics that they can collaborate about.

Their collaboration with each other and other teachers in the community is vital for developing collective activities.

The school-principal delegated all decisions about the implementation of development objectives to stakeholders within the primary science teacher community. Peter and Susanne are key-players in the process of negotiating what and how development activities should be implemented in the primary science teacher community. Their role is also to engage the other primary science teachers in the development process.

FINDINGS

In this section some findings about possibilities and constraints of developing collective activities within the science teacher community is presented. The findings relates to the three dimensions of McLaughlin and Talberts framework. In the last part of the section the teachers own assessment of the outcome of the development project are presented and discussed.

SUPPORTIVE LEADERSHIP TO DEVELOP THE TEACHER LEARNING COMMUNITY

Research shows that supportive leadership is important for the success of educational change processes (Fullan, 2007; Hargreaves & Fink, 2006). As discussed earlier there are four levels of leadership in the NaTeKu-project. In this section I will elaborate on the two levels inside the school: The role of a community coordinator and the principal.

The role of a "community coordinator"

Research on community-building in business has shown that a skilled *community coordinator* is a key-factor in developing an effective community of practice (McLaughlin & Talbert, 2006; E. Wenger, McDermott, & Snyder, 2007). The coordinator work both to organize the community's work and to building an effective learning environment for the community.
In the particular case presented here Peter and Susanne share the role of being community coordinators in activities in the NaTeKu-project. Peter focus on both organizational issues and building the collaborative practices. The following excerpt shows what role he plays:

> I: *What has participation in the NaTeKu-project mattered for the primary science teachers in this school?*
>
> Peter: *It means that we have focused on developing new ideas about teaching and what we want to improve. For example is working with innovation something new. […] But we have also started to work on developing a curriculum that creates coherence between primary science in the middle department and other science subjects in the other department.*

In this excerpt Peter argues that they have focused on two activities in the NaTeKu-project: Developing new teaching ideas (innovation as a curriculum topic) and creating a coherent curriculum that will ease student transitions between the different departments. The teachers in the community agreed to commit to a collective curriculum that covered 50% of the teaching in primary science. This is a big issue for many teachers in Denmark, because there is a long tradition about teacher-autonomy in planning their teaching.

Peters' role as a community coordinator includes promoting communication between members and departments, to ensure that all are informed about the progression of the community in different departments.

However, there are problems with Peter's role as a community coordinator. When I asked another primary science teacher, George, whether he participated in the development project, he answered: *Yes I do […] but I don't actually know who the coordinator is […] I assume that its' Peter. But it is a long time since I heard from him about the project.* George expresses doubt about who the coordinator in the project is, and that it is a long time since he was involved. George is associated to the lower department which is physically isolated from the other departments. They are situated in their own building. This means that George does not have a daily contact with the other primary science teachers involved in the project. So collaboration and discussions with other primary science teachers are scarce, compared to other primary science teachers in the community.

These problems expose two important constraints in the process of engaging all primary science teachers in the community in the developmental activities. First, it is crucial for all stakeholders in the development process to be informed about who has the role as community coordinator, and what his or hers tasks are. Clear information about division of responsibilities is crucial for all stakeholders to develop ownership towards the development activities. In the excerpt George states that he is not well informed about who the community coordinator is, and what his own responsibility is. Second, Georges' association to the lower department imposes a structural constraint on his possibility to engage in daily discussions with other members of the primary science community. For Peter, as the community coordinator, it is important to spread communication about community activities to ensure that e.g. George develops commitment towards the collective activities within the primary science teacher community.

Susanne's role as a coordinator is more to mediate ideas about best practice and inspire others with new tools and ways of teaching. The following excerpt is an example of how another community-member perceive Susanne's role:

> Paul: *Because of our good collaboration in primary science it becomes visible to other teachers what is going on in this subject. She [Susanne] is very creative on teaching and presenting student products. And to get her classes engaged in external teaching activities. So it becomes very visible that we are active in primary science out here. If you walk down the corridor there are many student products from primary science visible. It is difficult not to sense that it is an important subject.*
>
> I: *How does Susanne's creativeness affect you?*
>
> Paul: *Well, it does a little bit,[…] I think that in some way or another you want to surf on the wave that she has produced.*

Paul is a young teacher and a newcomer in the community. He is building his identity as a teacher. We can infer that Susanne's creativity inspires Paul to develop his own professional identity.

Principals' role in transition phases and creating space for collaboration within in school organization

The principal and vice-principal play an important role in supporting change processes. They work along the line of decentralizing decisions to teacher communities about issues that are meaningful for the teachers to express an opinion about. That includes decisions about engagement in and planning of developmental processes. The following excerpt exemplifies how the principal works on creating space for developing teacher-collaboration within the school:

> Principal: *Teachers' engagement in decisions about issues that affects their daily work ensures that they have ownership towards the joint practice of the school. That also includes the primary science teachers' participation in building their community. We [the principal and vice-principal] helped to initiate the developmental project in the primary science teacher community, but withdrew quickly from the negotiations to ensure, that the teachers developed their ownership. But we helped them in formulating the objective on developing a coherent curriculum in science within and between the departments.*

This excerpt shows that the principal was engaged in the beginning of the development project. Actually he initiated the process, because participation in the project was offered by the municipality. And then the principal saw it as an opportunity to develop the collaboration within the primary science teacher community further. After deliberations with the principal, the primary science teachers took initiative and developed their ownership towards the objectives of the development project.

However, the principals' quick withdrawal from designing the development activities also posed a constraint. McLaughlin and Talbert (2006, chp. 4) discusses how proactive leadership is important in all phases of developing a teacher learning community. This is in particular crucial in the early phases of the process of negotiating how development activities are designed and what roles should be played by different actors in the community. In the community under study, the principal withdrew too soon from these negotiations, leaving the responsibility of the negotiation to the community members. The consequence was that not all members of the community were well informed about division of responsibility of the collective activities, and what the role of the community coordinator was, as discussed earlier.

The activity of developing a coherent curriculum within and between the departments is only one amongst several activities that teachers in the community are engaged in. The teachers do not engage equally in all the activities. The principal argues: *Most of the teachers in the science teacher community are core-members in at least one activity. It is a success that so many teachers are committed to the activities in the community.* However teachers' different position in different activities also poses a problem, because a particular teacher that plays an active role in one activity needs to be kept informed about other activities if she/he is to play a peripheral role in these. I observed that this basic level of information transfer was not always present with all members in the community. The principal reflected: *I have to reassess my role in initiating and defining development activities in the future. It is very important that all members in an activity are informed about the objectives, division of labor and who is responsible for the activities.*

Another example of the principals' role in developing the primary science teacher community is in moderating the transition between different stages of the culture.

A few years back he initiated a development process about mapping the different ways of teaching primary science in the school. The objective was to moderate a discussion about how the primary science teachers could collaborate more. The teaching culture was individualistic at that time. Many old teachers taught primary science, and they argued that they could not see the value of sharing knowledge about teaching in primary science. Peter and Susanne argued: *The old teachers were used to planning and teaching being a private matter*. But an opportunity to change this culture appeared because many new teachers that teach primary science were employed in the following years. The young teachers were more interested in sharing knowledge about planning and teaching primary science than the old teachers. And then the NaTeku-project provided the opportunity to develop joint activities within the primary science teacher community.

The principals' engagement in initiating the development processes proved to be vital to transform the culture within the primary science teacher community.

THE DYNAMIC STRUCTURE OF COLLABORATION WITHIN THE SCIENCE TEACHER COMMUNITY

There are some characteristics about the dynamic structure of collaboration within the science teacher community.

First, the core of collaboration in the science teacher community is developing a variety of curriculum and teaching activities. In general there were two levels of collaboration between teachers in the activities. The first level of collaboration was in *micro-communities* where teachers collaborated in small groups on developing joint teaching activities. Teachers in the community valued collaboration in micro-communities because it was a shared space where they could discuss not only practical and pedagogical issues of their teaching practice, but also personal aspects of their life. I observed that teachers in micro-communities were more open about discussing attitudes and values about issues that related to the school culture. In this sense, micro-communities can be a secure space where teachers negotiate their attitudes with colleagues with whom they share personal relationships. The second level of collaboration was *large scale collective activities* that engaged many teachers in the science community from different departments e.g. in developing a coherent curriculum in science. Large scale collective activities were often initiated by the school principal in collaboration with a few teachers that would act as community coordinators for this particular activity.

Second, the *dynamic* notion emerges from observing that the structure of collaboration can have different *configurations* within the teacher community depending on teachers' involvement in different activities. Each configuration corresponds to different activities in the community and reflects that teachers are more or less active in the different activities.

Third, in one particular configuration of collaboration (e.g. the activity of developing a coherent curriculum) there are three degrees of *membership* (see figure 1): Core members, active members and peripheral members (E. Wenger et al., 2007). *Core members* are teachers that take on a pro-active role in activities that constitutes a particular configuration of collaboration. They often initiate actions within the activity and play the role as community coordinators. In the particular configuration presented in figure 1, the role as community coordinator was divided between Peter and Susanne. As the community matures core members will take on the leadership, and move the community along the learning agenda of the activity. *Active members* play a re-active role in activities. They will attend the activities regularly and play an auxiliary role in collaboration with the core members. *Peripheral members* rarely play an active role in activities. They will watch the interaction that takes place between the core members and the active members and show moderate interest for the activity. As teachers' collaboration progresses over time some micro-collaborative environments might mature and produce examples of good practice and teaching.

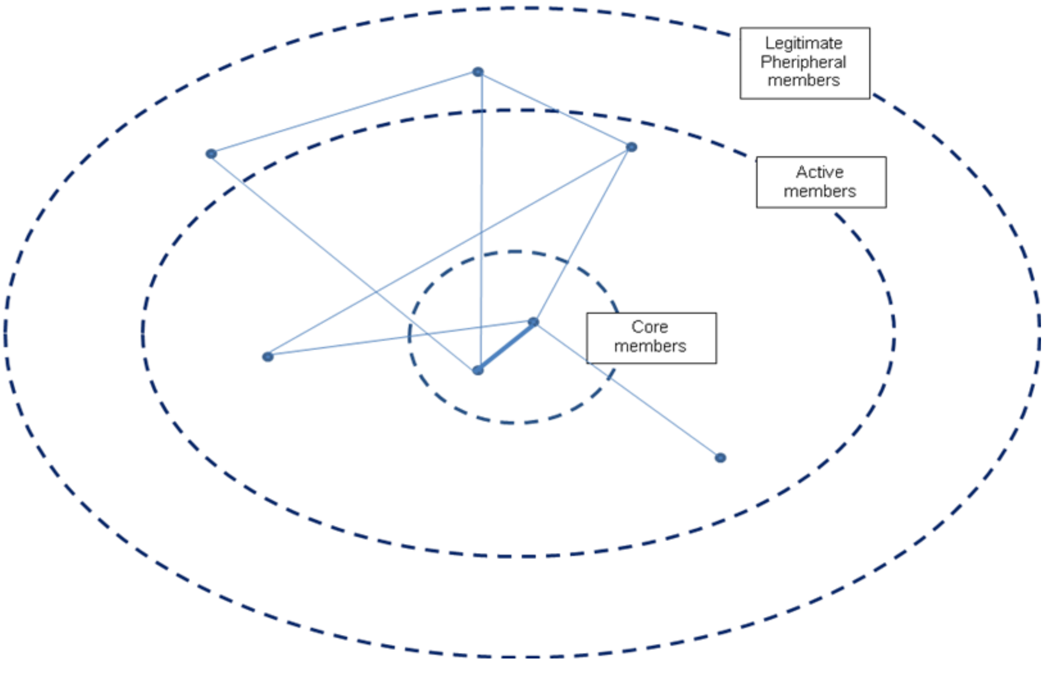

Figure 1: *Structure of collaboration of one activity in the community.* *In this case the activity of developing a coherent curriculum. Each dot represents a member of the community and each line represents a micro-community. A member of the community can have different degrees of memberships in different configurations of collaboration. In this particular case the there are two core members, three active members and two peripheral members.*

Fourth, the strength and quality of collaboration in the science teacher community depends on teachers' mutual engagement in collective activities and that they can have different positions in different configurations of their collaboration. Wenger argues that mutual engagement in collective activities is important for the sustainable development of the community (E. Wenger, 1999-2002). But as Susanne reflected: *It is not possible to be equally engaged in all activities in the community. You can be active in some activities and that have a more passive role in other activities.* This argument resonates with Wengers argument that diversity in community-members involvement is an important quality of mutual engagement.

TEACHER COLLABORATION ON DEVELOPING A COHERENT CURRICULUM IN PRIMARY SCIENCE

The primary science teachers and the principal agreed on that developing a local coherent curriculum in science within and between the departments was the primary objective of the development process.

This included that teachers' within the primary science teacher community started to collaborate about sharing best practice and developing new ways of teaching. But this shift from working individually to collaborating about planning and teaching was difficult, as can be seen in the following excerpt:

> Susanne: […] *it's an interplay. If I bring something, and sense that I get nothing in return, then the collaboration slowly seeps out. So collaboration is a question of equal engagement in some sense.*

Susanne argues that mutual engagement is important about developing the collaboration. Said in another way, lack of mutual engagement poses a constraint on developing collaborative activities.

Another example concerns her perception of collaborating with a science colleague in a micro-community:

> Susanne: *Regarding 6th grade. There Karen and I collaborate closely about planning and teaching in the two classes. Thus when Karen has taught about rocks, then she will come back and discuss what went well and what went bad […] that is, we have a much closer collaboration now about sharing practice. Because this is what we agreed on. It also means that we talk a lot more together now about teaching.*

Susanne emphasizes the quality of collaborating closely with a colleague about the teaching in primary science. Her collaboration with Karen focused both on assessing teaching, planning and developing new ways of teaching. In interviews and observations I found, that the teachers in general emphasized the interplay with other science colleagues in micro collaborative environments in their daily work.

What this means in relation to the objective of the developing the primary science teacher community as a whole, is that collaboration about sharing best practice and new ways of teaching must build on the teacher relations created in micro environments. Otherwise there is a risk that the collaborative processes cannot give meaning to the individual teachers own practice in primary science.

The joint effort of Peter and Susanne as community coordinators in the development process is crucial for this process to succeed. And they have to keep up the process over long time, because progress can be slow (McLaughlin & Talbert, 2006). But research has shown, that over time teachers come to see themselves as members of a professional community within the school (Stein, Silver, & Smith, 1998).

OUTCOME FOR TEACHERS AND STUDENTS

In the third phase of the NaTeKu-project, the teachers assessed how the development of collaborative activities affected their collective as well as individual practice.

In a group-interview the teachers and principal were asked to validate McLaughlin and Talberts' model as a diagnostic tool to assess the development of their community. Susanne argues that the model emphasizes the necessity to activate peripheral members to develop a shared responsibility and ownership towards the collective practice in the community:

> Susanne: *The model makes good sense in explaining the different roles people can have in different activities. It also emphasizes that active members in the community and the principal have to focus on activating peripheral members of the community. If some teachers tend to be peripheral in many activities it is difficult to develop a shared responsibility and ownership to the collective practice of the community.*

But both teachers and the principal agree that Susanne's point represents a minor problem because many teachers in the community are involved in diverse activities and they play different roles in various activities. The principal argues that there is a strong sense of shared responsibility and ownership in the community because most of the teachers play an active role in at least one of the various large scale collective activities. However, as the principal argues, activities that are initiated to improve to collective practice in the community have to be meaningful to each member otherwise there is a risk that the teachers engagement in sustaining the community becomes superficial. On the other hand the principal argues: *If the collective activities are important to each teacher's own practice, then the members might sense a strong connectedness to the culture in the community.* The principal's argument outlines an important criterion for developing collective activities within the community that makes sense in each individual members own practice.

Teacher's collaboration about developing a coherent curriculum is an example of an activity that stimulates the community members to sustain the community. In their final assessment community members concluded *that developing the coherent curriculum stimulated an increased responsibility towards the collective practice in the community*. They also argued that coherence in curriculum-activities between all departments has an impact on students learning outcome. Indications of this is that students transited from e.g. grade 6 to grade 7 act more competent in reflecting scientifically with procedural and declarative knowledge.

CONCLUDING REMARKS

The findings presented here show how the data provided the researchers with information about possibilities and constraints on developing collaborative work within a particular primary science teacher community.
This information is important to assess what actions to take to ensure success in achieving the objectives of a change process.
A summary of all the findings have been reported back to the school and the managing body of the project to help guide specific initiatives.
The framework of McLaughlin and Talbert's address many factors that are important to consider in changing the local science culture of a science teacher community. Data from this analysis will help to answer the research questions.

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THE INFLUENCE OF PARENTS, TEACHERS, AND CELEBRITIES IN YOUNG PEOPLE'S CHOICE OF SCIENCE IN HIGHER EDUCATION

Jørgen Sjaastad

Department of Physics

University of Oslo, Norway

jorgen.sjaastad@matnat.uio.no

ABSTRACT

Science role models are often held up as one way to increase the recruitment to educations within science, technology, engineering, and mathematics (STEM). In a national survey in Norway, 5722 STEM students answered questions regarding *persons* and how they might have inspired and motivated a STEM related educational choice. *Parents* are proven essential. Results indicate that parents can inspire such a choice even without having education in STEM subjects themselves. Moreover, findings suggest that the father is the main source of inspiration. *Teachers* also come forth as important individuals. However, students in theoretical STEM educations highlight the influence of teachers more than students in applied STEM educations. *Publicly known people* are often suggested as influential science role models. However, most STEM students attribute famous people with a minor degree of influence for their educational choice. It is suggested that the influence of celebrities on Norwegian youth primarily is indirect, through defining which values and activities are associated with different STEM related careers. *Personal relationships* are essential in order to inspire and motivate STEM related educational choices. Initiatives taken to increase recruitment could benefit from not only having youth, but also those in personal relationships with youth as a target group.

Keywords: *Science role models; recruitment; parents; teachers; celebrities.*

INTRODUCTION

In Norway, as in many other Western countries, there is a lack of candidates with competence in science, technology, engineering, and mathematics (STEM). This fact is elaborated in different reports, e.g. *Europe needs more scientists!* (EU, 2004). To handle a growing population, increased consumption, and other economical, technological, and environmental challenges, it is essential that the work force holds necessary qualifications within STEM. Moreover, although not discussed in most political reports, educations within STEM can offer opportunities for self-development and joy. Both individual and societal needs can be met in these subjects.

Consequently, increasing attention is directed towards recruitment to STEM related educations. Science role models are among the frequently mentioned factors in such discussions. Most commonly, parents, teachers, and celebrities are highlighted as important. These three groups of people are, however, very different in the way they relate to youth.

Thus, actively making use of individuals to increase the recruitment of STEM students requires knowledge about the specific ways these people influence youth's attitudes towards STEM.

In the present paper we investigate to what degree parents, teachers, and publicly known people have inspired or motivated STEM students' educational choices. Furthermore, we discuss in what ways these persons influence youth for whom they function as *significant others*. Responses to a national survey in Norway will be analysed to achieve this.

THEORETICAL FRAMEWORK

Individualization is a prominent feature of Western modern cultures (Myers, 2002). One's identity is defined in terms of personal attributes and not so much in terms of the group one belongs to. For example, being considered an intellectual depends more on one's educational history than to whether or not one belongs to an "intellectual family". Moreover, individuals exercise a reflexive pattern in their development: The self-view is continuously revised based on the present external information. Through this reflexivity, the individual searches for self-realization. Self-realization in late modernity involves pursuing one's perceived "true identity" and the activities one finds meaningful (Giddens, 1991). This pursuit is no longer constrained by gender, family, or socio-economic background, or so it is perceived by youth. The modern constraint is given by *oneself:* One has to be true to one's self. Taconis and Kessels proposed that choosing science depends on students' individual fit to "science culture" (Taconis & Kessels, 2008). They identified a "gap" between pupils' self-image and their image of peers who preferred science. Many high school and college students consider science as difficult, uncreative, and socially isolating (Masnick, Stavros Valenti, Cox, & Osman, 2010). Being true to one's self disfavours a STEM related choice for those with a negative perception of science.

In this context science role models are valuable, since they display traits, patterns of behaviour, and meaningful ways to live and demonstrate how these can constitute a coherent self. The self and others does not exist as mutually exclusive social facts (Cooley, 1902). One hundred years ago, Cooley claimed that no consistent view of the self could describe it as distinct from other persons, and that every thought is some kind of response to influence from the surroundings. Today, we have an extensive amount of research describing in different ways how individuals comprehend each other. By observing and reflecting on other people's actions, traits, appearance, and reactions to the individual itself, the reflexive development is facilitated (see e.g. Bandura, 1977; Giddens, 1991; McClelland, 1951; Mead & Morris, 1934; Myers, 2002).

In particular, a person's attitudes are continuously influenced by the people on whom he depends (Mead & Morris, 1934). These people are in the tradition of Cooley and Mead commonly referred to as *significant others*. Woelfel and Haller describe the significant others as persons who exercise major influence over the attitudes of individuals (Woelfel & Haller, 1971). They have developed a framework to categorize the ways in which significant others contribute to the attitude formation process, and they make a distinction between definers and models. The *definers* hold expectations for the individual (1) by communicating definitions of the individual's self or (2) by communicating definitions of an object. An example of the first could be the parents who throughout their daughter's adolescence tell her that she is sympathetic and should be working with people. They could furthermore tell her about how science is a social activity, thereby communicating definitions of science as an object. The *models* influence attitudes (3) by displaying an example of an individual, as the geeky professor in the evening news exhibits one way to be a geologist, or (4) by displaying an example of an object, as the teacher guiding her students through a fascinating exercise of mathematics applied to water supply. Note that these four acts are not mutually exclusive. A particular significant other can contribute to the attitude formation process in different ways at the same time. A mathematics teacher can display interesting mathematics and play her role as a mathematician, and at the same time communicate to her students their traits and abilities, making her both a model and a definer.

Apparent from the previous paragraph, role models are in this context considered as a subgroup of significant others. Roles can be seen as clusters of norms, traits, and actions, which a person holding a specific social position can display in a given social setting (McClelland, 1951; Myers, 2002). A role model is then, strictly speaking, a person modelling a specific role, showing an example of a role one may choose to adopt (Gagné, 1985; Goffman, 1959). This way of defining a role model is primarily covered by the third category in the framework of Woelfel and Haller.

Two general results are of special interest for our discussion on how significant others influence attitudes towards STEM. Firstly, attitudes are rarely changed in one occurrence. The internalization of these involves a gradual transformation. To stimulate attitude change is much like trying to push a piano uphill: "It is not impossible, but one shove won't do it" (Myers, 2002). Attitude change takes continued effort. Secondly, the influence of a significant other might very well be subtle and non-conscious, unintended by both the individual and the significant other (Chartrand, Dalton, & Fitzsimons, 2006; Aarts, Gollwitzer, & Hassin, 2004). Aarts et al suggest, through six different studies, that individuals may automatically and without conscious awareness adopt and pursue goals implied by other people's behaviour.

METHOD

The results presented here stem from a national survey in Norway, administered in order to deepen the understanding of Norwegian youth's educational choices. Using paper-and-pencil questionnaires, data was collected from undergraduate students beginning STEM educations in August 2008. No sample was drawn; all educational institutions offering STEM educations were invited to collect data. Non-responses were mainly due to university or college administration not finding the opportunity to administer the questionnaire. We estimate that more than 95 % of students who actually received the questionnaire responded. Our respondents constitute more than 70 % of the total population of Norwegian first-year students within these subjects. 1/3 of the respondents are female, which is also representative for the population of STEM students. All data was collected during students' first week in university or college. The present study builds on responses from a sub-sample constituted by 5722 respondents studying mathematics, geosciences, informatics, physics, chemistry, biology, pharmacy, marine subjects, engineering, and graduate engineering.

The questionnaire was designed to give the students a chance to reflect upon their educational choice. It was constructed based on empirical findings and theoretical perspectives from previous research on young people's educational choices and their relationship to STEM (Angell, Guttersrud, Henriksen, & Isnes, 2004; Eccles (Parsons) et al., 1983; Eccles & Wigfield, 2002; Jacobs & Simpkins, 2006; Schreiner, 2006). The questionnaire was validated through hearings with the project reference group as well as a focus group with STEM students responding to the questionnaire pilot. Most questions were closed check-box questions with a 4-point Likert scale scored from 1–4. The two extremes were labelled, and for the question to be analysed here, labels were "to a minor degree" (1) and "to a major degree" (4):

> *To what degree have you been inspired or motivated for your educational choice by the following?*

The students were asked to answer this question considering five different groups of people, namely "teachers", "friends and/or sweetheart", "parents, step-parents and guardians", "siblings", and "other acquaintances". "Publicly known people in the media" appeared as an item later in the same question. For the present analysis, the Likert scale is treated as an interval scale, giving the opportunity to calculate mean scores. The analysis will focus on robust findings using the simple statistics of counting and mean scores.

In addition to the check-box questions, three open-ended questions were included in the questionnaire. Here, the respondents were invited to write about different aspects of their educational choice. In this article analyses will be done on these responses simply by counting which *persons* are mentioned.

RESULTS

The total of 5722 STEM students' responses is in favour of parents as sources of inspiration and motivation to a STEM related educational choice:

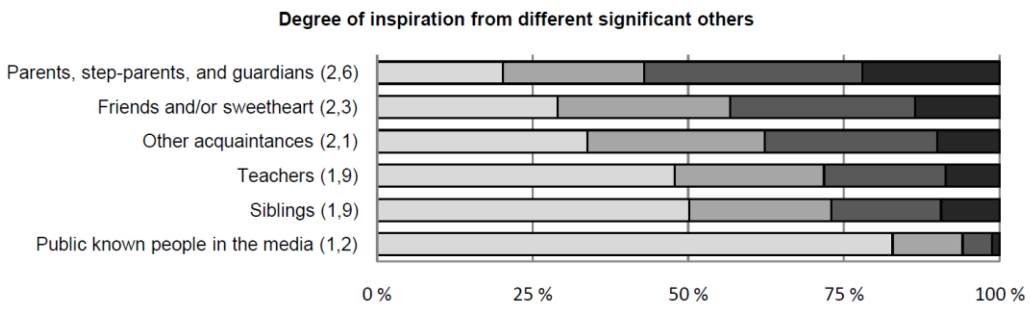

Figure 1. *"To what degree have you been inspired or motivated for your educational choice by the following?" Percentages in the four response categories from "to a minor degree" (light grey) to "to a major degree" (black). The groups are sorted by mean scores (in parentheses).*

PARENTS, STEP-PARENTS, AND GUARDIANS

Among the suggested significant others, STEM students rank parents as the most influential individuals for their educational choice. Parents are the only significant others with a mean score above the midpoint of 2,5. According to Figure 1, a total of 57 % of the students rank their parents in the top two categories.

In the questionnaire, the respondents were encouraged to answer some questions regarding their background. One of these concerned the educational background of their parents: "Does at least one of your parents/step-parents/guardians have education within mathematics, natural science or technology (e.g. engineering, technician, researcher, teacher in mathematics, biology, chemistry, physics, etc.)?" Of our 5722 STEM students, 48 % responded "yes", 48 % responded "no", and the remaining 4 % did not know. Splitting the students into these three groups yields the following regarding parents' influence on a STEM related educational choice:

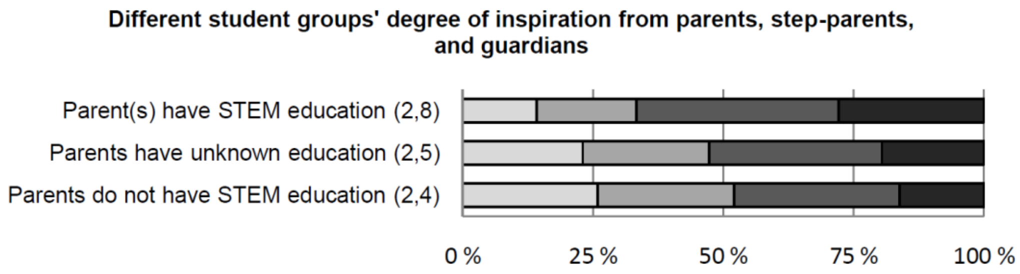

Figure 2. *"To what degree have you been inspired or motivated for your educational choice by the following?" Percentages in the four response categories from "to a minor degree" (light grey) to "to a major degree" (black). Student groups are sorted by mean scores (in parentheses).*

As displayed in Figure 2, there seem to be moderate differences between the students having STEM educated parent(s) and those who have not. However, among the students without STEM educated parents, 48 % still rank parents in the top two categories. Among all students claiming to be inspired and motivated to a major degree by their parents (Figure 1), 36 % report that their parents do not have an education within science, technology, engineering or mathematics. That is, parents do not need education within STEM to inspire a STEM related educational choice.

In the open-ended questions, parents are frequently mentioned. However, a great deal of these refers only to the father. Altogether, different versions of words referring to fathers are mentioned 216 times. The corresponding number of words referring to mothers is 45. This means that four out of five times a particular parent is reported to have inspired or motivated a STEM related educational choice, it concerns the father. Unfortunately, the question about parents' education does not distinguish between the mother's and the father's education. However, statistically we know that more men than women have a STEM education, which may be part of the explanation for fathers' dominance as sources of inspiration for STEM choices.

TEACHERS

The respondents rank teachers relatively low compared to parents, as seen in Figure 1. In the figure we see that a total of 48 % of the STEM students claim that teachers to a minor degree have inspired or motivated their educational choice. This seemingly low ranking is counterbalanced in the open-ended questions. Among the 5722 respondents, teachers are described 457 times. That is, 8 % of our respondents, and 25 % of those who mentioned persons in their descriptions, chose to write about one or several teachers when given a chance to reflect about their educational choice. This is the highest proportion received for any category of significant other.

The relatively low average score received by the teachers in the check-box question may hide interesting differences between subgroups. In fact, dividing the respondents into groups according to their specific choice of subject gives the following result:

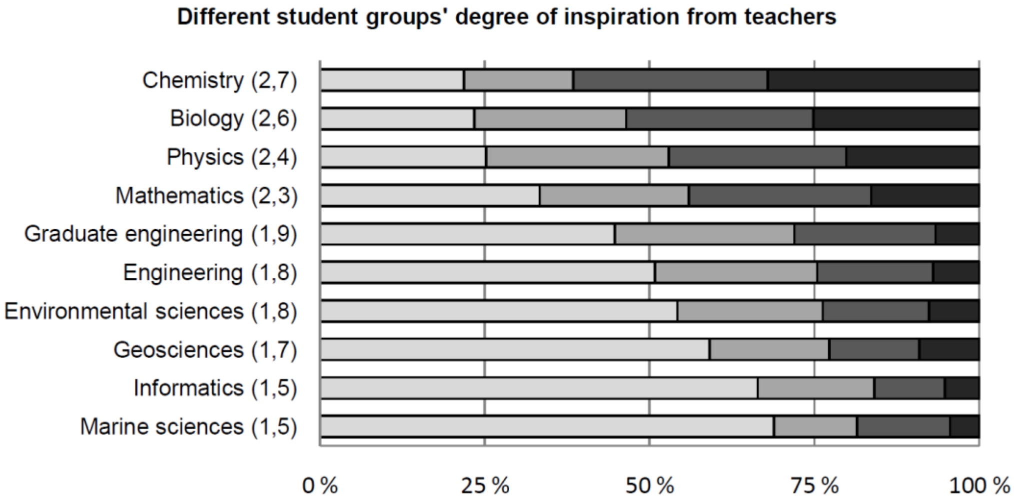

Figure 3. *"To what degree have you been inspired or motivated for your educational choice by the following?" Percentages in the four response categories from "to a minor degree" (light grey) to "to a major degree" (black). Student groups are sorted by mean scores (in parentheses).*

Respondents studying chemistry, biology, physics, and mathematics rank their teachers higher than do the students in other STEM subjects. These four subjects are strikingly similar to the science and mathematics discipline courses offered in upper secondary schools in Norway. Thus, it appears that teachers inspire and motivate more to traditional science and mathematics discipline subjects in higher education, and less to applied or technologically oriented STEM educations.

PUBLICLY KNOWN PEOPLE IN THE MEDIA

STEM students only attribute famous people with a minor degree of influence. As displayed in Figure 1, publicly known people in the media get a mean score of 1,2. A total of 83 % of the respondents claim that these people to a minor degree have inspired or motivated their educational choice. The 65 individual students claiming to be inspired by famous people to a major degree only total just above 1 %.

A related question in the questionnaire concerned films and TV series. The bioengineering students stand out from the other STEM students:

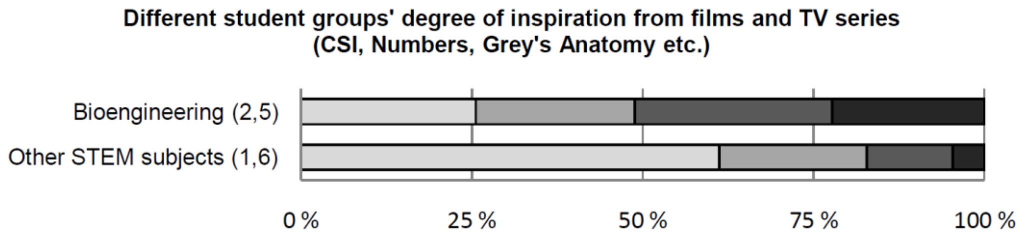

Figure 4. *"To what degree have you been inspired or motivated for your educational choice by the following?" Percentages in the four response categories from "to a minor degree" (light grey) to "to a major degree" (black). Student groups are sorted by mean scores (in parentheses).*

The first example of a TV series given in the questionnaire is CSI. CSI is short for "Crime Scene Investigation": Appealing crime technicians investigate and solve murder cases. In this TV series, bioengineering is used as a tool to reveal the truth. CSI is popular in Norway, and responses given in the open-ended questions confirm that a large proportion of the bioengineering students are indeed inspired by this particular TV series.

DISCUSSION

The present results will here be discussed in the framework of Woelfel and Haller, where the significant others operate as models and definers.

SIGNIFICANT OTHERS AS MODELS

Youth in Western modern countries have the freedom to choose among a wealth of educations and careers. However, it seems like despite individualization trends, young people often choose the *familiar*. STEM students rank their parents as most influential for their educational choice. In particular, fathers are highlighted. This could be due to the current gender imbalance in the Norwegian work force. Fathers are more commonly employed in STEM related professions; hence they can be models to a greater extent. The focus on fathers in the open-ended questions indicates this modeling effect and the fact that the familiar choice is a likely one. In some way, one can identify the same effect among those inspired by teachers and famous people. Those inspired by teachers often choose higher education within disciplines that correspond closely to the classical school subjects and more seldom within applied or technological fields. The few STEM students inspired by TV series also know, or at least hope to know, something about what they will do at work. Modeling is an important way to display which careers exist. Parents with STEM professions, teachers, and publicly known professionals can all be models both by modeling a particular role and by displaying the actual subject, thereby inspiring youngsters to make a choice of the familiar.

Publicly known people in the media are, however, attributed with a minimal degree of influence by the STEM students themselves. We cannot conclude from our results why this is. It could be that the Norwegian media picture does not hold enough science role models, or that the ones that do exist are uninspiring. Perhaps Norwegian youth is not susceptible to this kind of influence, or there might be some negative feelings associated with claiming to be influenced by celebrities ("everyone but me is fooled by commercials"). However, the fact that bioengineering students are inspired by the TV series CSI shows that models in the media can have a great effect. Moreover, the influence of significant others is often non-conscious. Different STEM related professionals might have been portrayed in the media without girls or boys using this information actively to make an educational choice. However, by this exposure the models contribute to which values and activities are associated with the particular STEM subject. These factors are essential in the reflexive process of self-realization, and the gap between youths' self-image and their image of those who practice science might be bridged.

SIGNIFICANT OTHERS AS DEFINERS

The high ranking of the parents is not only due to the modeling effect of fathers. In fact, the present results show that one does not need to have a STEM education to inspire a STEM related educational choice. Parents are in a special position to operate as definers. Long standing personal relationships are essential for the self-development of youth. Next to parents, friends are ranked highest among the significant others. Teachers are ranked low, but in the open-ended questions STEM students report how individual teachers have inspired their educational choices. Famous people are not reported to have had a major influence. Conclusively; it seems like the *personal relationships* are the key issue for recruitment of STEM students. Attitude change is a tedious process, and "one shove won't do it" (Myers, 2002). Lasting personal relationships give the opportunity to be a significant other. As definers, parents and friends can affect the way young people think both about themselves and about STEM, bridging the gap between young people and science from both sides. One does not need any STEM training to tell about the importance, usefulness, and joy offered by science, technology, engineering, and mathematics.

CONCLUSION

Parents are essential in the self-development of youth, given the opportunity to help young people define themselves. As definers, parents can also inform about issues related to STEM. Some parents, most commonly fathers, might furthermore have STEM training and can be models, displaying an example of a professional and displaying the subject itself. Teachers also have the opportunity to be both definers and models, due to the combination of personal relationships with pupils and their professional training. It is suggested that more applied STEM in Norwegian schooling can help teachers inspire to a wider range of STEM educations. Publicly known people are not proven essential for recruitment, although given the chance to be models. However, they might still influence educational choices indirect through their display of different STEM related careers. Conclusively, the present results indicate that initiatives taken to increase recruitment to STEM educations could be aimed not only directly at youth, but also at those in personal relationships with youth. Parents, teachers, and other "significant others" can help youth see themselves as STEM students and future professionals.

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WHAT IS GOING ON IN THE NORWEGIAN SCIENCE CLASSROOM?

Wenche Sørmo

Nesna University College

ws@hinesna.no

Bjørn Sture Pedersen

Nesna University College

bp@hinesna.no

Frode Henanger

Nesna University College

fh@hinesna.no

Johs Tveita

Nesna University College

jt@hinesna.no

Atle Ivar Olsen

Nesna University College

ao@hinesna.no

ABSTRACT

This study presents results from a questionnaire sent to 224 former science students from Nesna University College. One aim was to investigate to what extent they used teaching like fieldwork and active learning methods, when working as teachers. They were asked about their practice in the classroom and to what extent they wanted to change it. About 73% of the former students that answered were working as teachers and 58% and 96% of them have pupils doing fieldwork 1-3 times/year in primary and secondary school, respectively, while 47% and 77% respectively, wanted to do this more often. Few teachers let their pupils design/plan experiments in half of the lessons or more both in primary and secondary school, but as much as 71% and 83%, respectively, wanted to do this more often. This is in contrast to the amount of theory presented to the pupils where 52% and 76% of the teachers in primary and secondary school, claim to do it in half of the lessons or more, but only 5% and 8%, respectively, want to do this more often. Compared with other countries in OECD, Norwegian schools have few lessons in science, but experience an extensive curriculum and little time available to teach science under optimal conditions.

Keywords: *teaching, questionnaire, activity, teacher education, classroom*

INTRODUCTION

At Nesna University College, we have been giving specialized courses in science for teachers since 1978. We emphasize the use of active learning methods like fieldwork and performing of experiments in the classroom to achieve constructivistic thinking by the pupils, when educating teachers (Zoller et al., 1997). Learning by doing, discovery learning and inquiry-based learning are also variations of the fundamental thinking which are included in the term constructivism (Bruner, 1974, Imsen, 2005, Spronken-Smith et al., 2007). The courses aim to create an environment where the students participate actively in hands-on science activities and discussions to prepare them to create effective science learning environments for pupils in primary and secondary school. The relation between the science teacher education and the teaching practice in school has been studied by Andresen and Tveita (1993). We also use drama as a teaching method for our students, since studies have shown that drama can enhance and facilitate the understanding of both basic but also complicated concepts (Tveita, 1996, 1998, Ødegaard, 2003, Sarıçayır and Bayar, 2008). Visits to local industries and museums are also included in the science teacher education. It is important that the education prepares the teachers for the job in school and that the becoming teachers have had the opportunity to try out different activities during the education. It should therefore be easier to do the same activity together with pupils and the teacher should feel more comfortable in the teaching role. As teacher educators, we wanted to investigate to what extent the active learning methods in the education courses were adopted in the science classrooms and asked our former science students about what they did in the classroom in a questionnaire (Olsen et al., 2008, 2010).

MATERIALS AND METHODS

A questionnaire was sent out in February 2008 to all former science students having at least 30 sp (one half year full time study) in science in Nesna University College in the period from 1990 to 2007. The participation in the study was voluntary and the questionnaire was sent by mail. The questionnaire was sent to a total of 224 former students. To record the former students view on teaching practice in the classroom, they were asked to specify how often different kinds of teaching activities occurred. They could respond on a Likert scale of *Never 1, Some classes 2, About half of the classes 3,* and *Each or almost each class 4.* They were also asked weather they wanted to change their practice in the classrooms and they could answer *More seldom 1, No change 2* and *More often 3.* The incoming data was coded and entered in a SPSS datasheet. The respondants were treated anonymously and the data were analyzed with SPSS (version 17.0 for Windows) statistical program as described in Olsen et al., (2008 and 2010).

RESULTS

A total of 116 (52%) of the former students answered and returned the questionnaire. Of these, 85 (73%) former students were working or had been working as teachers, 38 (45%) of them were men and 47 (55%) were females. Of these, 47 were working in primary school with pupils from 1st to 7th grade and 26 were working in secondary school (8th to 10th grade). The rest of the teachers (12) were working in high school or had a job both in primary and in secondary school and they were therefore not included in this study.

Activity in the Classroom

The former science students (now teachers), seem to use active learning methods to a great extent in their teaching of pupils in primary and secondary school. The results from the investigation are presented in Table 1 and are compared to the Norwegian results in the TIMSS-2007 report (Martin et al., 2007).

Table 1. Percent of science teachers educated from Nesna University College report on what is going on in *half of the lessons or more* **in primary and in secondary school, compared to the "Teachers reports on Students doing Science Report" from Norway from the TIMSS-2007 study of pupils in 4th and 8th grade.**

Activities in the classroom	Primary-school	Secondary school	TIMSS-2007 4th grade*	TIMSS-2007 8th grade*
Pupils do experiments:	28	42	5	28
Teacher demonstrate experiments:	17	8	2	10
Work together in small groups on experiments and investigations:	44	40	7	30
Design or plan experiments and investigations:	11	12	3	14
Relate what students are learning in science to their daily lives:	56	65	42	54
Observe natural phenomena and describe what they see:	33	42	11	8
Teacher lecturing theory:	52	76	-	-

*Data from Martin et al., (2007).

The findings (Table 1) indicate that the teachers who have specialized in science from Nesna University College have much activity in the classroom, both in primary and in secondary school and that the pupils work in small groups doing scientific experiments or they observe natural phenomena and are allowed to describe and discuss what they see. However, 56% and 65 % of the teachers answer that they use half of the lesson or more on relating the science to the pupil`s daily life in primary and secondary school, respectively (Table 1). Presenting theory for the pupils in a lecture seemed to be an activity that is dominating both in primary and in secondary school and 52% and 76%, respectively, of the teachers do this half of the lesson or more (Table 1).

Drama and outdoor activities

The science teachers were asked how often they used drama and role play in science and how often they had their teaching outdoors. Both field work, outdoor teaching and drama in science are activities that we emphasize in the science courses at Nesna University College. The results are presented in Table 2. The teachers were allowed to answer *Never, 1-3 times/year, Every month* or *Every week* to these questions.

Table 2. Percentage of the science teachers educated from Nesna University College having drama and outdoor activities at different frequencies, when teaching in primary and secondary school.

	Primary school (n=45)				Secondary school (n=26)			
	Never	1-3 times/year	Every month	Every week	Never	1-3 times/year	Every month	Every week
Drama/Role play	30	59	9	2	25	71	4	0
Fieldwork/Excursion	6	58	26	8	0	96	4	0
Visit to museum e.g.	36	62	2	0	46	54	0	0
Outdoor teaching	9	30	26	35	42	46	8	4

These findings show that our teachers relatively often do outdoor activities, both in primary and in secondary school, but that the frequency decreases some in secondary school. As much as 70% and 75% of the teachers use drama and role playing in science 1 and 3 times each year or more often in primary and in secondary school, respectively. We also see that fieldwork and excursions are very common at school. In primary school 58% of the teachers work in the field with their pupils 1-3 times/year and as much as 26% do this every month. In secondary school 96% of the teachers work in the field or go on excursions with their pupils

1-3 times/year, but only 4% do this every month. Visits to museums, science centers or factories take place less often and 36% and 46% of the teachers never do this activity, but nevertheless 62% and 54% of the teachers in primary and secondary school, respectively, claim to do it 1-3 times/year (Table 2).

The wish to change teaching practice

We also looked into to what extent the science teachers educated from Nesna University College wanted to change their teaching practice. The result from the questionnaire is presented in Table 3 and shows in which direction the teachers wanted to change their practice in primary and in secondary school.

Table 3. Percent of science teachers educated from Nesna University College that want to change their teaching practice in primary school (1st-7th grade) and in secondary school (8th-10th grade).

	Primary school (n=43)			Secondary school (n=23)		
Activities in the classroom	**More seldom**	**No change**	**More often**	**More seldom**	**No change**	**More often**
Pupils do experiments:	0	37	63	0	46	54
Teacher demonstrate experiments:	2	60	38	0	61	39
Work together in small groups:	0	55	45	0	61	39
Design or plan experiments and investigations:	0	29	71	0	17	83
Relate what students are learning in science to their daily lives:	0	70	30	0	58	42
Observe natural phenomena and describe what they see:	0	67	33	0	58	42
Drama/role playing:	0	51	49	0	36	64
Fieldwork/Excursions:	2	51	47	0	23	77
Visits to museums and factories:	0	19	81	0	32	68
The teacher gives a lection:	2	93	5	4	88	8

The results presented in Table 3 show that the science teachers wanted to increase the amount of pupil-activities in the classroom, both in primary and in secondary school. More than 50 % of the teachers answered that they wanted to let the pupils do more experiments, let them design and plan experiments and investigations and go to visit museums and factories more often, in primary school. In primary school, the teachers seemed to be satisfied with the way science was related to the pupils daily lives (70%), with the amount of experiments that were demonstrated (60%) and with the amount of theory that was presented to the pupils (93%) (Table 3). In secondary school, more than 50% of the teachers wanted their pupils to do more experiments, design and plan experiments and investigations, do more fieldwork and visit museums and factories more often. These teachers were satisfied with the amount of experiments demonstrated for the pupils (61%), with the organization of the class in small groups (61%) and with the amount of theory presented (88%) (Table 3). Presenting theory was the only activity the teachers, both in primary and in secondary school, not wanted to do more. Only 5% and 8 % of the teachers in primary and secondary school, respectively, answered that they wanted to do this activity more often (Table 3), but only 2% and 4% reported that they wanted to do the activity more seldom.

DISCUSSION

Results from TALIS (Teaching and Learning International Survey, (Vibe et al., 2009).) showed that the majority of secondary grade teachers in all participating countries (OECD) were females and that Norway was among the countries with the highest proportion of male teachers (40%). This reflected our survey where 45% of the science teachers were males.

However, Olsen et al., (2010) found that the teachers goals with their science teaching and hence, their teaching practice, seemed to be independent of gender.

Findings shown in Table 1 indicated that the science teachers educated from Nesna University College had a high degree of pupil-activity in their lessons. Compared with the results from Norway in the TIMSS-2007 International Science Report on: “Teachers` reports on students doing science investigations” where the numbers reflects “percentage of students whose teachers reported students doing the activity about half of the lesson or more”, our former students seemed to have more activity in the science classroom (Table 1), (Martin et al., 2007). However, this could partly be due to the fact that our numbers, especially in primary school, reflected the activity in the classroom from 1st to 7th grade and it is likely that there is more activity in the lowest grades and that this percentage therefore is considerably higher than the numbers from the TIMSS report. Our former students seemed to have less activity in secondary school (8th-10th grade), especially in the activities: “Teacher demonstrates experiments” and that the pupils to a smaller extent than the 8th grade teachers in the TIMSS study, are allowed to “Design or plan experiments and investigations” (Table 1). However, as indicated in Table 3, 39% and 83%, respectively, of the teachers in our study, claim that they want to do these activities more often in secondary school.

Also activities like field work, drama and going on excursions to e.g. museums and science centers seemed to be activities that our teachers wanted to do more of, both in primary and in secondary school (Table 3). However, they seemed to be satisfied with the amount of new theory that must be introduced to the pupils and they did not want to do this activity more often (Table 3). They were also satisfied with the way they relate what students are learning in science to their daily lives (Table 3). Table 3, shows that a majority of the teachers wanted to have more activity in the classroom, but Table 1 show that they already had a lot of activities in science compared to other teachers in Norway. Ellingsen et al., (2010) have in their study tried to find out why the science teachers want to have so much activity and what hinder them in having more activity.

Results from UNESCO show that Norway compared to other countries gives much less time for teaching in science (Sjøberg,1992). This has almost not changed in later years. Almost all the teachers in our questionnaire answered that it was enough theory in science, only 5% and 8% wanted to teach theory more often in primary school and secondary school, respectively, but most of the teachers wanted to do more activities, demonstrations and experiments (Table 3). Results from the PISA (Programme for International Student Assessment) project run by the OECD (Organization for Economic Cooperation and Development) show that Norwegian pupils seem to score low in natural science compared to other OECD countries (Kjærnsli et al., 2007). The score of more than 20% of the pupils is below or at level 1 and only 23% of the pupils score at or above level 4 in Norway compared to 18% and 28% below or at level 1 and above level 4, respectively, in the OECD countries (Kjærnsli et al., 2007). The TIMSS 2007 International Science Report shows an average of 8% and 11% science instructional time of total instructional time implemented in the school in the 4th grade and 8th grade, respectively for all countries in the investigation. For Norway, the numbers were lower; 5% and 10% of total instructional time at school were used on science in 4th grade 8th grade, respectively (Martin et al., 2007). Our results show that the former science students use active learning methods when working as teachers, and that they define science as a practical topic. It seems like our science courses, to a high degree, are reflected in the science classrooms. However, the amount of theory in science is high in primary and secondary school. With few lessons in science on the schedule, the teachers have to make priorities and it seems like they focus on working through the curriculum, even though their wish is to do more activities. The teachers are faithful to the curriculum and want to secure that they will go through everything with their pupils, but if there is any spear time, they add activities that will enhance the pupils understanding of science.

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WHY IS IT HOTTER IN SUMMER THAN IN WINTER? K-5 STUDENTS' & PRE-SERVICE ELEMENTARY TEACHERS' CONCEPTIONS OF SEASONAL CHANGE

Ioannis Starakis

University of Athens

gstarakis@hotmail.com

Krystallia Halkia

University of Athens

kxalkia@primedu.uoa.gr

ABSTRACT

In the present study, primary school students' and pre-service teachers' ideas of Seasonal Change, are investigated. The research was carried out in nine primary schools of Athens and in the Primary Education Department of the University of Athens. Written reports were used for gathering data while students had also the opportunity to support their answers with drawings. The results showed the following:

1) Pre-service teachers address notions which involve the movement of the Sun and/or the Earth while primary school students address human centered, tautological and phenomenological notions as well.
2) Both primary school students and pre-service teachers adopt mainly two Schemes of explanations; alterations in the distance between the Sun and the Earth and alterations in the Earth–Sun relative orientation/illumination.

Keywords: *K-5 students, Pre-service teachers, Sun-Earth-Moon system, Seasonal Change.*

1. INTRODUCTION

In the past three decades many researchers have examined children's and adults' ideas of basic astronomical events (see Bailey & Slater 2004). Some of these studies concerned Seasonal Change (Baxter 1989, Mant & Summers 1993, Sharp 1996, Atwood & Atwood 1996, Galili & Lavrik 1998, Parker & Heywood 1998, Trumper 2001, Frede 2006, Hsy 2008).

The most common results that can be extracted from these studies are:

- Young students address notions which involve near and familiar objects/phenomena (clouds, day length, weather phenomena, etcetera).
- As they get older they replace them with others which involve the movement of the Sun and/or the Earth.
- The most common notion is the one which attributes Seasonal Change to the variations in the distance between the Sun and the Earth (Baxter 1989).

However, in many cases, significant deviations are recorded among certain studies, either in the percentages or the existence of a notion itself, without any further justifications. For example, while in Baxter's (1989) and Trumper's (2001) studies, a high percentage of 15-16 year old students attributed Seasonal Change to the inclination of the Earth's spinning axis (around 50%), the corresponding percentage in Galili's & Lavrik's (1998) study was just 20%.

The present study is part of a broader research concerning the Sun-Earth-Moon system from an educational point of view and is based on the “Model of Educational Reconstruction”. In this model the understanding of students’ perspectives and the interpretation of the scientific content, are closely linked, aiming at designing new teaching and learning sequences (Duit et. al. 2005).

Consequently our study focuses on addressing and comparing Seasonal Changes’ conceptions of students in Greece who have never been taught the phenomenon before (k-5 students) with conceptions of students who have been taught it twice (pre-service elementary teachers), not as a means of exploring obstacles of learning but as points to start from and mental instruments to work with in further learning (Duit & Treagust 2003).

2. SEASONS (THE SCIENTIFIC MODEL)

The Earth’s spinning axis is not vertical to its revolution level around the Sun, but it forms a $23{,}5^o$ inclination, pointing always to the Polar Star. The combination of the Earth’s inclination and revolution around the Sun, results in Seasonal Change. Specifically, during the Earth’s revolution around the Sun, the hemisphere leaning towards the Sun is exposed to solar radiation more than the other since solar radiation prostrates more vertically to this hemisphere.

3. SEASONAL CHANGE IN GREEK CURRICULUM

In the Greek educational system, Seasons are taught either in elementary (6^{th} grade) or in high school (7^{th} grade) in Geography. The concerned textbooks present the scientific knowledge of the phenomenon ‘in black and white’, accompanied by explanatory figures. It has to be mentioned that students’ conceptions are not taken into account in these textbooks.

4. PRESENT STUDY

The present study took place: a) in nine primary schools of Athens, from different socioeconomic regions, with a sample of one-hundred and forty-two (142) 5^{th} grade students and b) in the Primary Education Department of the University of Athens, also with a sample of one-hundred and forty-two (142) undergraduate elementary pre-service teachers. Each of the participants had approximately 15 minutes to answer the following question in writing:
“*Why is it hotter in Summer than in Winter? How do you explain Seasonal Change on Earth?*”
Apart from giving a written response, both k-5 students and pre-service teachers had to support their answers with drawings. Two students and one pre-service teacher did not answer the question.

5. RESULTS

5.1 THEORETICAL FRAMEWORK

The answers of the participants were categorized according to a two-level hierarchical structure proposed by Galili (1995). According to this model of categorization, several seemingly different explanations (**Facets of knowledge**) may be expressed. However, they can share a common explanatory mechanism (**Schemes of knowledge**). For example, the notions that *“Seasonal Change is caused by alteration in the distance between the Sun and the Earth, due to Earth’s elliptic orbit around the Sun”* and *“Seasonal Change is caused by* *alterations in the distance between the Earth's north and south hemisphere with the Sun, due to the Earth's tilt of its spinning axis*" are two different Facets of the same Scheme (*alteration in the distance between the Sun and the Earth*) .

5.2 SCHEMES

So, according to both k-5 students and pre-service teachers, responses, the following Schemes were identified:

1. Angle of sun rays incidence on Earth
   *(*For example: *In Summer, sun rays prostrate on Earth more vertically than in Winter)*
2. Alteration in the Earth-Sun relative orientation/illumination
   *(*For example: *As the Earth spins, the part that 'sees' the Sun has Summer and the other part has Winter)*
3. Alteration in the distance between the Sun and the Earth
   *(*For example: *In Summer, the Earth comes closer to the Sun, while in Winter the opposite happens)*
4. Mixed (combinations of 1,2 and 3 schemes)
   (For example: As *the Earth follows its elliptic orbit around the Sun, it sometimes goes further away, compared to other points of the orbit. This is when we have winter. This also has to do with the Earth's spinning. When certain places of Earth don't 'look at' the Sun, these places have also winter.)*
5. Phenomenological notions
   *(*For example: *Clouds block Sun rays in Winter)*
6. Human centered notions
   *(*For example: *If there was no Summer, we wouldn't go on vacation)*
7. Tautological Notions
   *(*For example: *In Summer the temperature is high)*
8. Not classified Notions
   *(*For example: *God created the Seasons)*
9. Fragmented Notions
   *(*For example: *The Seasons change because the Earth orbits the Sun)*

Table 1 presents the frequency of answers of each Scheme and each population of the sample, while Figure 1 presents the corresponding percentages.

Table 1: Frequency of answers of each Scheme and each population of the sample

(SCHEME)	Number of K-5 Students	Number of Pre-service Teachers
1. Angle of sun rays incidence on the Earth	1	17
2. Alteration in the Earth-Sun relative orientation/illumination	33	21
3. Alteration in the distance between the Sun and the Earth	26	62
4. Mixed (combinations of 1,2 and 3 schemes)	0	6
5. Phenomenological Notions	21	4
6. Human centered Notions	21	5
7. Tautological Notions	8	0
8. Not classified Notions	8	3
9. Fragmented Notions	22	23
Total	N=140	N=141

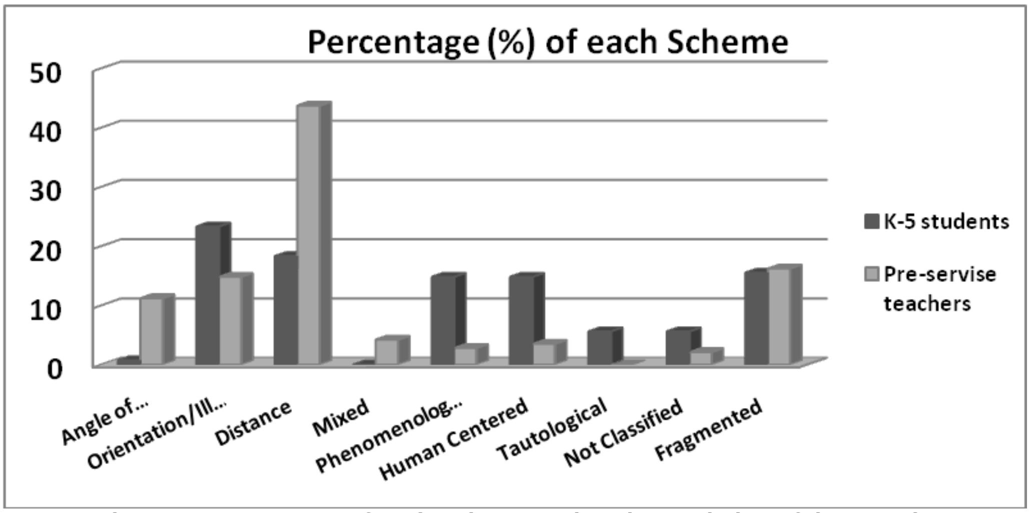


Figure 1: Percentage of each Scheme and each population of the sample

5.3 DATA ANALYSIS

5.3.1 Angle of sun rays incidence on the Earth

Only one k-5 student (0,7 %) used this causal mechanism in his reply, being at the same time far from the scientific model. This student wrote:

> *In Winter the Sun goes under the Earth and hits it sideways with its rays, while in Summer the Sun comes in front of the Earth and hits it vertically with its rays …*

This was a presumable result since k-5 students: i) have never been taught the phenomenon before ii) their everyday experience couldn't lead them to the adoption of such ideas.
Regarding pre-service teachers, the corresponding percentage (11,2%) was not high, bearing in mind that they have been taught the phenomenon twice. Among these university students (N=17), only one came close to the scientific explanation. The rest either just mentioned "The angle of Sun rays incidence on Earth", without any further explanation:

> *During Summer sun rays strike the Earth vertically. In Winter, sideways…*

or tried to combine unsuccessfully and not thoroughly this causal mechanism with the Earth's rotation around the Sun:

> *As the Earth orbits the Sun, in Summer sun rays strike more vertically in certain places while in Winter they strike sideways…*

5.3.2 Alteration in the Earth-Sun relative orientation/illumination

A number of k-5 students (N=33 or 23,3%) and pre-service teachers (N=21 or 14,8%) adopted the second Scheme, according to which, when a place of Earth is orientated towards the Sun it "receives" more sun rays and has Summer, compared to the places which "receive" less or no sun rays and have Winter. It seems that students who have adopted this Scheme of Knowledge confuse the causal mechanism of Seasonal Change with the one of Day and Night Cycle.

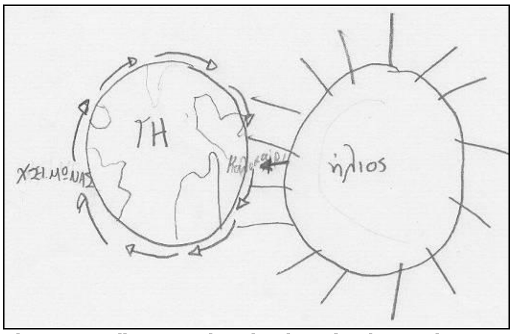
This Scheme, according to both k-5 students' and pre-service teachers' responses, manifested itself in five Facets (table 2). Each of them linked the alterations in the Earth–Sun relative orientation to the following movements:
a) The Earth's spinning (figure 2a),
b) The Earth's revolution around the Sun,
c) A combination of 'a' and 'b',
d) The Sun's revolution around the Earth
e) The Sun moving across the North and South hemispheres of the Earth.

There were also some cases where respondents just addressed the parameter of orientation without stating how this orientation changes. For example, one pre-service teacher wrote:

It has to do with the Earth's position compared to the Sun. When the Sun illuminates a certain place of the Earth, this place has Summer. The opposite place is not illuminated. This place has Winter. (figure 2b)

Table 2: Frequency of answers of each Facet within Orientation / Illumination Scheme

FACETS WITHIN ORIENTATION/ILLUMINATION SCHEME	Number of K-5 Students	Number of Pre-service Teachers
a) Earth orbits Sun	9	8
b) Earth spins	11	2
c) Earth rotates around Sun and spins	2	4
d) Sun rotates around Earth	2	2
e) Sun moves across north and south hemisphere of Earth	1	0
f) No further explanation provided	4	4
g) Fragmented explanation	4	1
Total	N=33	N=21



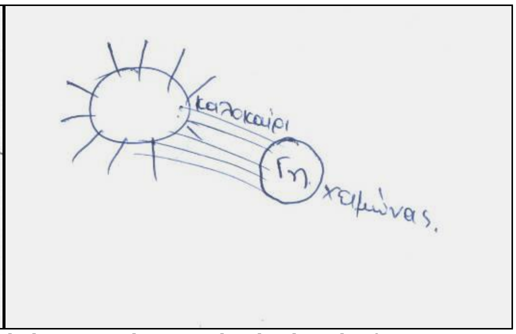


Figure 2a (k-5 student's drawing) Figure 2b (pre-service teacher's drawing)
In Greek "Καλοκαίρι" means "Summer" and "Χειμώνας" means "Winter".

Data analysis revealed a relative decrease in the corresponding percentages, from k-5 students to pre-service teachers. This decrease regards mostly Facet "b" which ascribes periodic alteration in the Earth-Sun relative orientation, to the Earth's spinning (N=11 for k-5 students, N=2 for pre-service teachers). This is consistent with the findings of bibliography, according to which as students get older, they adopt the scientific model of Day and Night Cycle in higher percentages (Baxter 1989). Hence, one could assume that pre-service teachers confront themselves cognitively if they try to use the same movement of the Earth (spinning) and the same causal mechanism (illumination of the Earth from the Sun) in order to explain two completely different phenomena (Day-Night Cycle, Seasons). A typical example of such a confrontation is the written answer of one of the two pre-service teachers who displayed Facet "b":

The Earth spins (but I am not sure if this spinning lasts one day or one year). Anyway, I would answer, that because the Earth spins around its axis, each season, the Sun illuminates us or not… If so, then what happens with day and night?

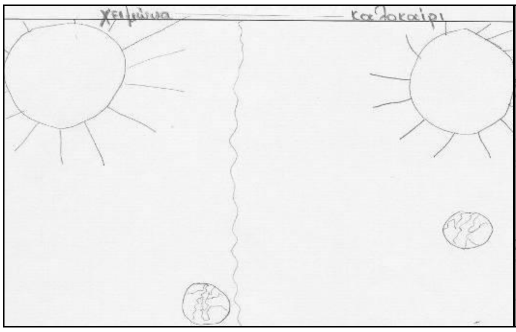
On the contrary, when the chosen movement differs from the one which explains the Day-Night Cycle (see Facets a, c, d, and e), there is not such a confrontation, as shown in the results. For example, one pre-service teacher, holding Facet "d", wrote:

According to the Sun's revolution around Earth, 3 months per year the Sun "illuminates" and warms a certain part of the Earth (Summer)...At the same time theSun doesn't "illuminate" the opposite part of the Earth (Winter).

5.3.3 Alteration in the distance between the Sun and the Earth

The basic root of this Scheme seems to be the everyday experience, according to which, the closer we come to a source of heat the warmer we feel (Halkia 2006). It is worth, however, stating that data analysis revealed a considerable increase of the corresponding percentages, from k-5 students (N=26 or 18,3%) to pre-service teachers (N=62 or 43,7%). Moreover, while k-5 students' highest frequency Facet of this Scheme (14 out of 26) refers to the simple statement that the Earth approaches and goes away from the Sun or vice versa (figures 3a, 3b):

> *When the Earth is close to the Sun we have Summer. When the Earth goes away from the Sun, Winter is coming…*



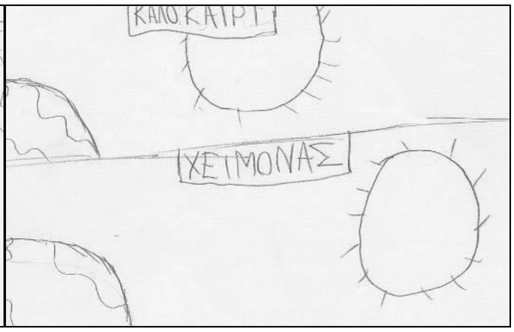


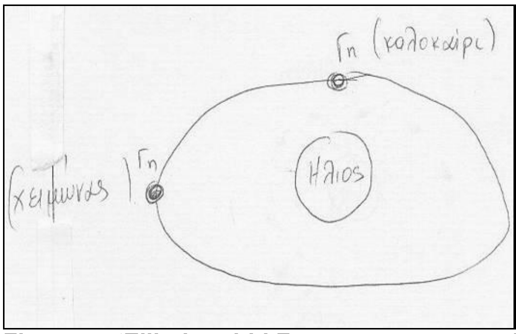
Figure 3a **Figure 3b**
(both are k-5 students' drawings)
In Greek "Καλοκαίρι" means "Summer" and "Χειμώνας" means "Winter".

Pre-service teachers' highest frequency Facet (27 out of 62) refers to the periodic variation in the distance between the Sun and the Earth, due to the Earth's elliptic orbit around Sun (figure 4a). One pre-service teacher explained:

> *Because the Earth's orbit is elliptic…Therefore, when it approaches the Sun we have Summer and when it is far from the Sun, Winter.*

Another Facet within this Scheme (only pre-service teachers displayed it) connects the Earth's tilt of its spinning axis with the variation in the distance between the Earth's north and south hemispheres from the Sun (figure 4b). There were seven (7) pre-service teachers (4,9 %) who held this Facet:

> *Because the Earth has a tilt. So, when the north hemisphere is near the Sun it has Summer and when it is far from Sun it has Winter.*



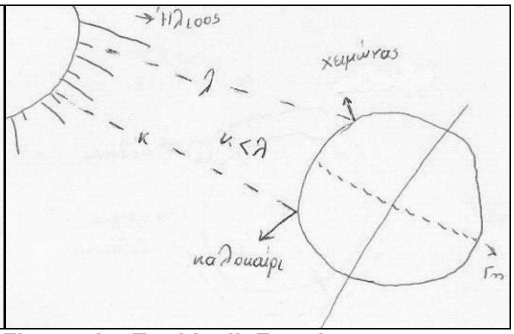


Figure 4a 'Elliptic orbit' Facet **Figure 4b: 'Earth's tilt Facet'**
(both are pre-service teachers' drawings)
In Greek "Καλοκαίρι" means "Summer" and "Χειμώνας" means "Winter".

There were also some replies in the context of "distance" dependence Scheme, either from k-5 students (N=5 or 3,5%) or from pre-service teachers (N=14 or 9,8%), which have never been recorded before on related bibliography. According to these responses, when a place on the Earth is orientated towards the Sun it has Summer since it is closer to the Sun than an opposite situated place. One pre-service teacher explained:

> *Because in Summer the part of the Earth where we stand is closer to the Sun, so it gets warmer. On the contrary, in Winter the same part is far away from the Sun, so it gets colder…*

(Figure 5 corresponds to the pre-service teacher who gave the above answer)

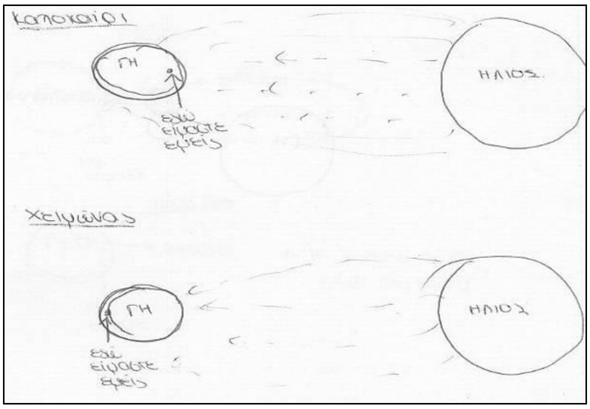


Figure 5 (pre-service teacher's drawing)
In Greek "Καλοκαίρι" means "Summer" and "Χειμώνας" means "Winter".

Given that teaching Seasonal Change in the Greek educational system does not step on the '*dissatisfaction with existing conceptions*' (Posner et. al 1982), it seems that, as time goes by, students incorporate declarative aspects of scientific knowledge (*elliptic orbit, tilt of the rotational axis, etcetera)* into the aforementioned "*distance"* dependence Scheme.

5.3.4 Mixed (combinations of 1, 2 and 3 schemes)
Only very few pre-service teachers (N=6 or 4,2%) gave responses within this Scheme. They tried to combine "*distance"* dependence Scheme either with '*angle incidence*' or with "orientation/illumination" dependence Schemes, resulting mostly in incoherent outcomes:

> *When we have Summer in Greece, sun rays strike vertically. At the same time the Earth is closer to the Sun due to the elliptic orbit around the Sun…*

5.3.5. Phenomenological Notions
K-5 students in a percentage of 14,8% (N=21) attributed Seasonal Change to : a) weather phenomena (snowing, sun shining e.t.c), b) clouds as obstacles for sun rays' propagation, c) warm and cold air-streams, d) day length and e) the change of the Sun's position on the horizon, during the year. In other words, they made use of everyday experienced objects and phenomena. The corresponding percentage for pre-service teachers is minimized (2,8% or N=4).

5.3.6 Human centered Notions
As far as the percentages of this Scheme are concerned, the picture is analogous to the previous one. Twenty-one (21) k-5 students (14,8%) related Seasonal change to human needs:

> *Because people can't survive only with cold, they need heat as well…*

That happens because we must swim in Summer... play with snow in Winter ... all kinds of flowers must blossom in Spring and make our city beautiful.

On the other hand, only 5 pre-service teachers (3,5%) adopted this Scheme:

In order to be able to adapt to all temperatures…

5.3.7. Tautological Notions

Only few k-5 students (N=8 or 5,6%) gave responses within this Scheme by reproducing the content of the question they were given:

…As time passes, seasons change. It is hot in Summer and it is cold in Winter. That is to say that for every season we have a different temperature.

5.3.8. Not classified Notions

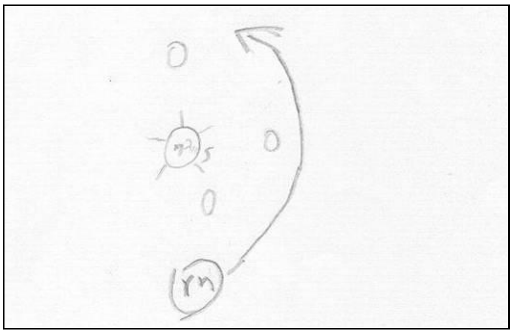
Some explanations (*God's will, hot and cold planets, natural warming and freezing of the Earth, molecules' movement, etcetera)* either from k-5 students (5,6% or N=8) or from pre-service teachers (2,1 % or N=3) could not fit to any of all the aforementioned Schemes and could not form distinguishable Schemes owing to their small number.

5.3.9. Fragmented Notions

Finally, twenty-two (22) k-5 students (15,5%) and twenty-three (23) pre-service teachers (16,2%) gave answers which either i) did not make any sense or ii) did not include any causal mechanism for Seasonal Change. Answers of category 'ii' just involved celestial movements (The *Earth's spinning, the Earth's revolution around the Sun, a combination of the two aforementioned movements, the Sun's revolution around the Earth*) *or* the tilt of the Earth's rotational axis:

As the Earth rotates around Sun, the weather changes…

(Figure 6a corresponds to the k-5 student who gave the above answer)
Seasonal change is owed to the Earth's tilt...
(Figure 6b corresponds to the pre-service teacher who gave the above answer)



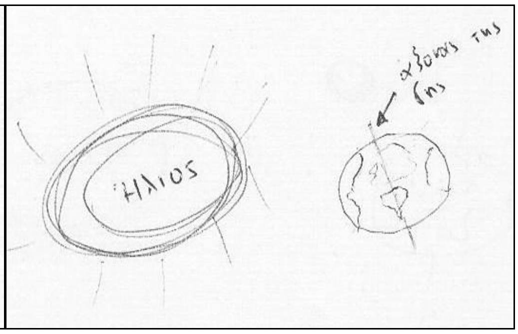


Figure 6a (k-5 student's drawing) **Figure 6b(pre-service teacher's drawing)**

Unlike other studies (Baxter 1989, Atwood & Atwood 1996, Galili & Lavrik 1998), the present study did not classify such answers to specific categories because, according to the model of categorization we followed, there was no accounting for why these movements or the Earth's tilt affect seasonal change.

6. CONCLUSIONS

Four basic conclusions could be drawn from the data analysis of our research concerning k-5 students' and pre-service teachers' conceptions of Seasonal Change:

1. Confirming previous studies (Baxter 1989), is seems that, as time goes by, children move from a) human centered, b) tautological and c) phenomenological notions to notions which involve Sun and/or Earth movements.

2. Despite the fact that pre-service teachers, unlike k-5 students, have been taught about Seasonal Change twice (both *in elementary and in high school*), very few of them adopt the '*Angle of sun rays incidence on Earth*' Scheme. The results showed that pre-service teachers, within this Scheme, cannot present a coherent explanation of the Seasonal Change. They only reproduce pieces of scientific information in a piecemeal fashion.

3. Both k-5 students and pre-service teachers adopt mainly: a) "Alteration in the distance between the Sun and the Earth" and b) "Alteration in the Earth-Sun relative orientation/illumination" as seasonal change's causal mechanisms. Regarding the "Alteration in the distance between the Sun and the Earth" Scheme, a considerable increase in related percentages, from k-5 students to pre-service teachers, takes place. This is mainly because, as time passes after having been taught at school, students "embody" in this Scheme all parts of scientific knowledge *(Earth's elliptic orbit around Sun* and *Tilt of Earth's rotational axis)* that can be assimilated, while they "reject" that part which cannot assimilated *(Angle of Sun rays incidence)*. That is consistent with previous studies on how students embody the culturally accepted views to their initial models (Vosniadou & Brewer 1994). As regards the "Alteration in the Earth-Sun relative orientation/illumination" Scheme, it seems resistant to change as long as it is not confronted with the scientific explanation of the Day and Night Cycle.

4. Conclusions 2 and 3 lead us to the final conclusion that teaching of Seasonal Change in school should step *firstly* on the dissatisfaction with students' initial Schemes and *secondly* on activities aiming at explaining why a different angle of the sun rays' incidence results in a difference in the Sun's radiation received.

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“EXTRATERRESTRIAL INTELLIGENCE” - SCIENCE FICTION LITERATURE IN SCIENCE EDUCATION: A CASE STUDY

Ioanna Stavrou,

University of Athens, Hellas

ioannakstavrou@yahoo.gr

Gianna Katsiampoura

National Hellenic Research Foundation, Hellas

katsiampoura@gmail.com

Constantine Skordoulis

University of Athens, Hellas

kskordul@primedu.uoa.gr

ABSTRACT

This study refers to the research conducted with primary school students examining whether they can identify the ‘scientific context’ through analyzing science fiction short stories involving extraterrestrial intelligence. In addition, we examine whether they can write science fiction stories of their own using scientific elements in order to make their stories plausible. The research was conducted with a sixth-grade primary school class of 30 students over a period of five weeks in two-hour sessions during which students read and analyzed science fiction short stories and wrote science fiction stories of their own.

Our data (worksheets and science fiction stories by the students) were analyzed with Qualitative Content Analysis. Our analysis shows that the students are able to identify the elements of the text referring to the ‘scientific context’ and associate them with the literary context of the stories. However, the students find it difficult to integrate ‘scientific context’ in their own stories.

Keywords: *science fiction, extraterrestrial intelligence, science education*

INTRODUCTION

In this world transformed by technological, economic, and ecological changes, the role of literary culture seems more important than ever. This is a fact that is recognised as an imperative in the field of Science Education, as recent decades have seen an increase in sociocultural perspectives within Science and Environmental Education that are reflective of the cultural turn in intellectual theory more generally. These critical, historical, political, and socioecological views, interested in access to scientific knowledge, education, and power, have become part of enlightened Science and Environmental Education discourses (Carter, 2008). In this perspective, the gap between the sciences and the humanities and the urgent need to confront it, do not exist on the theoretical level alone. Indeed, we face an increasing number of situations that Bruno Latour, variously describes as ‘borderline’ questions or ‘sociotechnical’ and ‘ethicoscientific’ imbroglios (Latour, 2003). These are intricately woven mixes that pertain simultaneously to the domains of the natural sciences and the humanities. Therefore, a sort of composite sciences-humanities literacy is required to help a democratic citizenry not only to scrutinize but also to contribute to science-and technology-based decisions about such imbroglios.

One way of investigating into these issues is through the literature of science fiction. With the genre's license to create new societies and worlds, it seems an ideal tool with which to explore socio-scientific alternatives. Moreover, as science fiction is so often taken to be the expression of political opinion or ideology of the scientific and technological society aimed at presenting alternatives to social condition, it functions as thought experiment and critical discourse which can also bring more skepticism about politics, ideologies and epistemological certainties in the context of Science Education (Gough, 2006, Weinstein, 2006).

Science fiction is an 'incubator' for imaginative minds to create visions that help us to glimpse not only the scientific present and future, but also something about ourselves, and functions as the integrator of socio-cultural space that supports the dialogue between science and humanities. Yet more, science fiction is a genre well-suited to express the concerns about environment and explore humanity's place in ecological systems since it encompasses a broad range of issues that derive from the interaction of humans with the natural word, and this literary genre's articulations contribute significantly to the broad rethinking of the relations between human and nature that is currently taking place specially in western societies (Merrick, 2005).

To bring science fiction into the science classroom is a way of "cross- fertilizing" the disciplines; yet these are precisely the sorts of things that can and should be done to open our students to broader intellectual perspectives. In reality, there is a great deal of overlap between the disciplines. The common thread that holds imaginative works and scientific works together is a celebration of the sense of wonder and awe that comes with addressing big questions about the nature of humankind and the universe our species inhabits (Brake *et al,*2006).

Science fiction as creative and innovative literary genre addresses complex questions about our role in the cosmos which is both cross-curricular and invigorating, demanding a widening knowledge of various disciplines, drawing together the disparate strands of science and the humanities, and generating application to our modern world and its broadening horizons (Griffiths, 2009). Science fiction narratives (stories) are considered as highly valuable resources for Science Education (Negrete, 2003). Negrete and Lartigue (2004) suggest that narratives are indeed an alternative and an important means for science communication to convey information in an attractive, imaginative and memorable way. To present scientific information through stories should be regarded as an important means to transmit information in the repertoire of both science teachers and science communicators (Van Dijck, 2003).

Science fiction is often roundly criticized by scholars and educators as misleading (Michael & Carter, 2001), as a significant source of students' misconceptions (Barnett *et al,* 2006) and sometimes as offering a distorted and stereotypical view of science and scientists, especially in science fiction films (Haynes, 1994:50-56; Thacker, 2005:140-142; Weingart, 2003). However, as science fiction can have a substantial impact on students' scientific ideas (Barnett *et al,* 2006) as well as on their cultural response on science (Bates, 2005) it is important that teachers and science educators not only be aware of the ideas that are presented in science fiction but also be ready to confront this issue in science teaching in the classroom. (Jane *et al,* 2007). Therefore, rather than avoiding using science fiction in schools it may be a better strategy to engage students in the critique of science fiction (Barnett *et al,* 2006).

This Case Study refers to the research conducted with primary school students examining whether they can identify the 'scientific context' through analyzing science fiction stories involving extraterrestrial intelligence as well as the ethical, moral, political and cultural issues raised in the stories. In addition, we examine whether they can write science fiction stories of their own using scientific elements in order to make their stories plausible.

This study is a part of a wider research project whose main aim is to examine whether science fiction texts can be used as supplementary educational material in a cross-disciplinary approach between Science and Humanities in Primary School (Stavrou & Skordoulis, 2008; Stavrou *et al,* 2009).

In this Case Study we have chosen the “extraterrestrial intelligence” issue taking advantage of the intense interest that young students have in the existence of extraterrestrial life to introduce them with the multidisciplinary sciences, as this issue involves astronomy, life sciences, earth sciences, biology, chemistry, and physics problems associated with the question of the existence of life inside or outside our solar system (Brake *et al,* 2006; Griffiths *et al,* 2001; SETI, 2003). Moreover, students are given the opportunity, through the subject of “extraterrestrial intelligence” to confront controversial topics, such as ‘otherness’ and to deal with moral and ethical issues as well as perspectives about humanity’s situation in the universe (Griffiths, 2009; Saunders *et al,* 2004).

In the condition of the classroom the concepts of “difference” and “commonality” regarding “extraterrestrial intelligence’, could be a starting point in understanding how acts of meaning and interpretation, identity, and ending of subordination can share similar features. Recognizing the similarities in feelings, in counteractions, despite the sundry differences that students have with extraterrestrial beings, sets no determining direction or final outcome for social conflict. At best, the struggles and hopes supported by this point of view share a sense of community, dialogue, and intersubjectivity that bind peoples (SETI, 2003).

METHODOLOGY

Due to the fact that this study is part of a wider research project aiming at examining whether science fiction texts targeted at adult readers could be used in the context of educational process in primary school, we designed and conducted the following Case Study (Yin, 2003).

Case Study Protocol

Research Questions

- Whether students can identify the ‘scientific context’ and associate it with the literary context of a science fiction text.
- Whether students can identify the ethical, moral and political issues raised by the extraterrestrial intelligence issue.
- Whether students can integrate scientific elements into literary context in their own stories.

Sample

The research was conducted with a sixth-grade primary school class of 30 students (12 years old) of 16th Primary School of Athens, situated in the centre of the city. The majority of them came from low-income and middle- income families. Thirteen (13) of the students were children of financial immigrants, five (5) of which faced difficulties in understanding Greek language.

Our research consisted of five two-hour sessions which covered a period of five weeks.

Over this period and during their physics lessons, we worked out the scientific viewpoint of extraterrestrial intelligence using magazine articles and the Internet.

Procedure - Implementation

I) Initially students were asked to answer a *Questionnaire,* which consisted of 4 open questions and 2 closed questions, in order for us to examine the students' perceptions of extraterrestrial intelligence as well as the students' knowledge of scientific inquiry concerning the subject. The questionnaire, in the context of the present study, was given to students as an introduction to the subject of 'extraterrestrial intelligence, therefore, it is not part of the conclusion procedure.

II) *Reading and analyzing the texts*: Thereafter, the students were presented with the following science fiction texts (stories) involving extraterrestrial intelligence and they were asked to study and analyze them, in order to reinforce their ability to examine, to associate and to justify both the scientific and literary elements in the text.

Science Fiction Stories

- "Report on Planet 3" (1959) by Arthur Clark (short story): Being a report of Martian scientists on planet Earth, yet containing the 'scientific assumptions' of earthly scientific community. It also addresses the 'what if 'assumption of science fiction.
- "The Heavenly Host" (1975) by Isaac Asimov (short novel): Newly arrived on planet Anderson Two, just before Christmas, Jonathan, child from Earth, is warned about the dangerous native inhabitants, but an accidental meeting with one of the natives convinces him that they are friendly and peaceful. He devices ways to communicate with an 'alien child' based on shared feelings rather than conventional language.
- "Moby Quilt" (2001) Eleanor Arnason (short novel): The teaming of disparate species (squid-like aliens and humans) together to investigate the possible sentience of one another. At its core the story is essentially an exploration of different kinds of intelligence. In this story AI (Artificial Intelligence) has the role of benevolent mentor.

The above texts were chosen on the basis of the following criteria: a) they were written by acclaimed and awarded science fiction writers b) they refer to socio-scientific controversial issues c) the extraterrestrial beings are depicted in a positive way.

The textual analysis was based on the elements comprising the "scientific context" of the stories. The term "scientific context" refers to scientific concepts, scientific instruments as well as the authors' scientific assumptions. In these particular texts it is concerned with the planet's position in the universe (planet or satellite), the planet's conditions (the composition of the atmosphere, climate, its flora and fauna), the references to scientific instruments, the extraterrestrial beings themselves and the ways of communicating with them as well as the authors' scientific assumptions.

Having read and analyzed each text, the students had to work on a *worksheet* on the 'scientific context' of the text, as well as the characters, their actions, the facts and the plot. The worksheets were designed in order for us to examine the students' ability to identify the literary elements, such as theme, plot, setting and conflict and associate them with the scientific elements of the stories, such as scientific concepts, instruments as well as the authors' assumptions. In addition, through the *worksheets,* we examined the students' ability to highlight any societal and /or ethical, moral and political issues raised by the extraterrestrial intelligence subject.

III) In the next stage, the students were asked to write their own stories in order for them to elaborate further on the issues presented. Even if they didn't manage to write a complete

story, they were asked to come up with a plot outline and then discuss how “scientific context” would play a role in the story they envisioned.
The students’ writing assignments were examined in the light of their references to:
a. The way in which they used the “scientific context”.
b. The way in which they used literary elements such as plot, characters, setting and their assumptions of the theme of extraterrestrial intelligence and the way they associated them with ‘scientific context’.

Our data (worksheets and science fiction stories by the students) were analyzed in accordance to “Qualitative Content Analysis” (Mayring, 2000, Krippendorff, 2004).

I) Worksheets: For each worksheet we established the following *categories* and *subcategories*

Category: Identification and recording of ‘scientific context’ of science fiction text.
Subcategories
Complete identification and recording of ‘scientific context’: worksheets containing complete identification and recording of scientific elements of ‘scientific context’ (scientific concepts, scientific instruments as well as the authors’ scientific assumptions).
Adequate identification and recording of ‘scientific context’: worksheets lacking one of the aforementioned scientific elements.
Deficient identification and recording of ‘scientific context’: worksheets lacking more than one scientific elements.

Category: Connection of ‘scientific context ’with literary context.
Subcategories
Setting: worksheets in which the scientific elements are associated with the setting of the story.
Characters: worksheets in which the scientific elements are associated through the characters.
Plot (‘scientific’ assumptions’): worksheets in which the scientific elements are associated with ‘scientific assumptions’ contained in the story line.
Conflicts: worksheets, in which the scientific elements are associated with conflicts, either these concern the characters or the plot.

Category: Ethical, moral, political and cultural issues
Subcategories
With reference to scientific research: worksheets that contain references to ethical, moral, political aspects of the scientific research presented in the text.
With reference to scientists: worksheets that contain references to ethical, moral, political aspects of the scientific community and scientists characters presented in the text
With reference to Human – alien encounter: worksheets that contain references to ethical, moral, political aspects of encounters between humans and aliens as presented in the text.

II) Science fiction stories written by the students
In order to analyze the science fiction stories written by the students we established the following *categories:*

Categories

Category: ‘scientific context’: stories in which students use scientific elements in order to make their story plausible.
Category: ‘literary context’: the literary elements of each story as setting, characters, plot.

Category: Integration of 'scientific context' with literary context: stories in which the scientific elements are associated with literary elements in order for the students to put forward their claims and reasoning.
The questionnaire was also analyzed with "Qualitative Content Analysis" but as we mentioned above, was given to students as an introduction to the subject because our study was conducted in class conditions.

RESULTS

I) Questionnaire

The scientific research concerning extraterrestrial intelligence.
As far as scientific research was concerned, 27 students mentioned NASA's and SETI's Projects, the radio telescopes as well as the Hubble space telescope, while only 3 of them mentioned, manned or not spacecraft missions.

Concepts and standpoints concerning extraterrestrial intelligence.
All the students held a firm belief in the existence of extraterrestrial beings. 25 of them claimed that there was extraterrestrial life in the solar systems of our galaxy or in other galaxies apart from ours. 21 of them considered the beings to have humanlike characteristics, including the ability to express emotions, and 19 of them believed that such beings possessed higher intelligence than that of humans.

Ethical, moral, political and cultural issues concerning scientific research for extraterrestrial intelligence.
16 students maintained that the scientific research for extraterrestrial intelligence promoted the advance and development of science and technology, while 18 of them believed that such research was carried out for the purpose of humanity's future colonization of other planets. Only 2 students believed that the research aimed at finding out the extraterrestrial beings' intentions concerning the earth.

II) Worksheets

- "Report on Planet 3":

Category: Identification and recording of 'scientific context' of science fiction text.	
Subcategories	
Complete identification and recording of 'scientific context'	28
Adequate identification and recording of 'scientific context'	2
Deficient identification and recording of 'scientific context'	-
Category: Connection of 'scientific context 'with literary context.	
Subcategories	
Setting	30
Characters	30
Plot ('scientific' assumptions')	27
Conflicts	28
Category: Ethical, moral, political and cultural issues	
Subcategories	
With reference to scientific research	30
With reference to scientists	30
With reference to Human – alien encounter	30

All students mentioned and elaborated on the subject of the 'scientific context' of the text, as it refers to a Martian scientists' report on Planet Earth. Students could link the text's 'scientific context' with literary context when the former had reference to setting, characters and conflicts, whereas they were confronted with some difficulties to define the 'scientific assumptions' which were enunciated to the plot of the story.

- "The Heavenly Host":

Category: Identification and recording of 'scientific context' of science fiction text.	
Subcategories	
Complete identification and recording of 'scientific context'	29
Adequate identification and recording of 'scientific context'	1
Deficient identification and recording of 'scientific context'	-
Category: Connection of 'scientific context 'with literary context.	
Subcategories	
Setting	30
Characters	30
Plot ('scientific' assumptions')	30
Conflicts	30
Category: Ethical, moral, political and cultural issues	
Subcategories	
With reference to scientific research	30
With reference to scientists	30
With reference to Human – alien encounter	30

The majority of students (29 students) mentioned and elaborated on the subject of the 'scientific context' of the text (planet's position, existing life forms – means of communication with them) and all of them associated it with literary elements.

- "Moby Quilt":

Category: Identification and recording of 'scientific context' of science fiction text.	
Subcategories	
Complete appreciation and recording of 'scientific context'	25
Adequate appreciation and recording of 'scientific context'	1
Deficient appreciation and recording of 'scientific context'	4
Category: Connection of 'scientific context 'with literary context.	
Subcategories	
Setting	25
Characters	30
Plot ('scientific' assumptions')	23
Conflicts	28
Category: Ethical, moral, political and cultural issues	
Subcategories	
With reference to scientific research	23
With reference to scientists	28
With reference to Human – alien encounter	28

While analyzing this text, which was the most difficult of the three, some of the students (5 students) couldn't soundly identify the scientific elements (as Artificial Intelligence) and associate them with literary context. These were the students that found it difficult to complete the worksheets as well, and they were the ones that had difficulties in Greek language. Nevertheless, these students (5) did remarkably well in the first two stories.

In all three texts (stories) students were at ease associating the scientific elements with literary elements as well as raising the ethical, moral and political issues involved, especially concerning scientific inquiry as well as the scientists' role. It's worth mentioning that all students paid special attention to the colonization of other planets convention, which was mentioned in two of the texts, and according to which, humans do not have the right to colonize planets where there is intelligent life.

Science fiction stories written by the students

Categories

Category: 'scientific context'

As far as the students' writing assignments (stories) are concerned, the "scientific context" was focused on the conditions of the planet (24) and the description of the beings (21), without however any effort on their part to associate the beings' appearance with the conditions existing on the planet.

Category: 'literary context'

Fictionally, their stories, mostly (29 stories) involving two characters - the child itself and an alien creature - were set on almost all occasions on another planet but earth, except one set on earth. The 'aliens' were always depicted as friendly beings that meant no harm to the human race and, most of the times (28 stories), were in need of help. The student protagonist, who in all of the stories held the role of a scientist, always prevailed without any evident conflict.

Category: Integration of 'scientific context' with literary context

The majority of students (29) failed to fully integrate the 'scientific context' in the 'literary context', in their stories, in accordance to science fiction conventions.
Ultimately, the students were eager to write a story and they took special care to present a piece of writing devoid of spelling errors.

CONCLUSIONS

Although the students were not familiar with written science fiction, they were at ease identifying, writing down the 'scientific context' of science fiction texts and making associations between the scientific and literary elements of a story, especially when presented with texts referring to subjects familiar to them.

Throughout the process the students were successfully motivated to get involved both in physics sciences and in fiction. In particular, the texts' reading as well as the worksheets, succeeded in arising all students' interest. Even immigrant students kept asking questions about definitions of unknown words. All students eagerly participated and managed to comprehend and process the "scientific context" and the literary elements of the texts. They also very easily processed the societal, ethical and moral issues raised concerning scientific inquiry, scientific community and human-alien encounter.

Because of their engagement with science fiction texts students were queried and discussed not only about scientific issues but also about social and scientific ramifications on finding intelligent life on another planet as well as human's role in the cosmos. Consequently, selective science fiction texts can be useful and effective teaching tools in Science Education.

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Science Fiction Stories
“Report on Planet 3” by Arthur Clark (1959)
“The Heavenly Host” by Isaac Asimov (1975)
“Moby Quilt” by Eleanor Arnason (2001)

AN ANALYSIS OF STUDENT TEACHERS' ATTEMPTS TO DEVELOP INTEGRATED SCIENCE AND TECHNOLOGY ACTIVITIES: A CASE STUDY AT A SOUTH AFRICAN UNIVERSITY

Michèle Stears

University of KwaZulu-Natal, Durban, South Africa

stearsm@ukzn.ac.za

James Mackay

University of KwaZulu-Natal, Durban, South Africa

mackayj@ukzn.ac.za

Hayley Bentham

University of KwaZulu-Natal, Durban, South Africa

202517547@ukzn.ac.za

ABSTRACT

The research reported in this paper was conducted to determine if student teachers enrolled in a Bachelor of Education programme at a South African University, are able to integrate Science and Technology in their teaching. The participants were a cohort of students registered for a course aimed at preparing them to teach in the primary school. The theoretical framework which frames this study is based on Rogan's analogy that curriculum strategies are good when they proceed just ahead of current practice i.e. are within the Zone of Feasible Innovation (2006). Students' understanding of integration was compared to their knowledge base. The findings show that students who intend teaching in the Grades 4 to 6 in the B.Ed programme generally have a poor grounding in Learning Areas such as Science and Technology. Given the reluctance of students to engage with these two learning areas, expecting them to engage in the integration of the two, is too difficult for the vast majority of students in this module. The ZFI for these students implies better preparation in the basic learning areas with regard to content as well as teaching strategies.

Keywords: *teacher education*, *integration, science and technology, curriculum strategies*

INTRODUCTION

One of the many changes implemented with the advent of democracy in South Africa, was the introduction of a new education system. The introduction of Curriculum 2005 (C2005), (DoE 1995) as a single national curriculum for everyone heralded a different approach in education as C2005 advocated an interdisciplinary approach to education. While the advent of a new innovative education system was widely welcomed, the problem of implementing such a radically different curriculum soon became evident. Curriculum developers had high hopes for this curriculum, but the reality was that implementation of this curriculum was more difficult than anticipated.

BACKGROUND

The B.Ed programme at a South African University contains three modules referred to as 'Learning Area Studies'. These modules are aimed at teaching students how to integrate the different learning areas as prescribed by the national curriculum (C2005). One of these modules focuses on the integration of the Natural Science and Technology Learning Areas

(LAS 310). This module is compulsory for students who register for courses preparing them to teach from Grades 4 to 6 (the intermediate phase). As C2005 expects teachers to present learning programmes in the Intermediate Phase in which Science and Technology are integrated, the aim of this module is to teach students how to effect such integration. Integration in this context refers to the ability to design activities for learners in which they achieve Learning Outcome 1 of Natural Science (Scientific investigation), as well as Learning Outcome 1 of Technology (Solving a technological problem). While the intention is a noble one, the reality is that a large number of students who register for this module had very little exposure to Science and Technology during their school years. Added to this, many students do not register for Science or Technology modules in the B.Ed programme. Such students come into the LAS 310 course with no background in Science or Technology. Those registered for the Grades 7-9 programme must register for at least one of the Mathematics, Natural Science or Technology Learning Areas. This is in accordance with the regulations set out in the Norms and Standards for Teacher Education (DoE 2000).The result is that students who register for LAS 310 often have little or no grounding in Science or Technology. Very few select both Natural Science and Technology as their Learning Areas of choice.

THEORETICAL UNDERPINNING AND LITERATURE REVIEW

The conceptual framework underpinning the study is an adaptation of Rogan's Zone of Feasible Innovation (ZFI), (2006). While Rogan used the construct to frame curriculum levels within a schooling context, the construct will be applied to innovation in the B.Ed curriculum in a teacher education programme. The ZFI is analogous to Vygotsky's Zone of Proximal Development (ZPD) which is defined as the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers (Vygotsky 1978 ,86).

Rogan uses the analogy that curriculum strategies are good when they proceed just ahead of current practice i.e. are within the Zone of Feasible Innovation (2006). The ZFI in this context comprises content knowledge, as well as teaching and learning strategies within the context of C2005 that are realistic and achievable (Rogan 2007). This would include compulsory modules in the Natural Science and Technology Learning Areas that are achievable for students selecting the Intermediate Phase for teaching. 'The strategies in the ZFI are regarded as stepping stones to some defined goal, which is not yet attainable given the prevailing context' (Rogan 2006, 441). The defined goal in this context is a course aimed at developing the skill of designing integrated science and technology activities, and this research is aimed at determining what the steps within the ZFI should be to attain this goal. While the use of the term innovation may be questioned with regard to student learning, its use is deemed appropriate as the curriculum for teacher education was designed to meet the needs of C2005 which is deemed a curricular innovation.

Rogan (ibid) describes his ZFI as 'a collection of teaching strategies that go beyond current practice, but are feasible given the existing resources available to the teacher, or group of teachers and the prevailing environment of the school in terms of its availability to foster and sustain innovation. In our adaptation of Rogan's ZFI we pay less attention to resources, than to student teachers' knowledge of science and technology which operates as the ZFI. We wish to determine what the steps would be that are deemed 'beyond current practice' but progress to the defined goal. In the light of this conceptual framework, the research question we wish to address is if the reason for many students' inability to integrate science and technology effectively in the design of activities is due to the fact that the structure of this B.Ed Programme is not within the ZFI?

In this module students are not only required to interpret and implement Learning Outcomes 1 of the Natural Science and the Technology Learning Areas respectively (Appendix 1); they are expected to design activities in which the two outcomes are integrated. Many researchers report on curriculum policies that are ambitious in their goals of implementing change over short periods of time. Hargreaves (1998) points to the fact that when intended change is too broad and ambitious it often results in no change at all.

Joseph and Brooks (2008) report on a project where an integrated science and technology approach was introduced in certain elementary schools in the state of New York. To facilitate this approach, teachers were required to observe demonstration lessons by the researchers with classes and engage in discussions after the lessons, prior to them attempting to apply this integrated approach themselves. It would appear that, despite the fact that teachers may be experienced, if their knowledge base is weak, curriculum change is very difficult.

If integrating Science and Technology in education appears to be such a challenge, it raises the question why South African curriculum developers would introduce integration in the Intermediate Phase, given the many challenges which confront education? One reason may be the realisation that developing a scientifically and technologically literate citizenry requires not only the inclusion of the two disciplines in the curriculum; it necessitates the understanding of the link between the two disciplines. A developing country such as South Africa is in dire need of scientific and technology literate citizens as this can alleviate poverty, while developing useable skills required by developing countries (Blueford & Rosenbloom 2003).It is for this reason that UNESCO (in Blueford and Rosenbloom) supported the development of an innovative curriculum to support developing countries This integrated Science-Technology-Mathematics approach lends credence to the integrated approach suggested by C2005. This approach aims to develop critical thinking that can be applied to problem solving in real life situations. The purpose of an integrated Science and Technology Curriculum in the Intermediate Phase is to develop precisely these skills which are demonstrated with the achievement of the Natural Science and Technology Learning Outcomes 1 respectively. For teachers to facilitate the development of such skills, they should possess these skills themselves.

Technology is very much part of our lives- we live in a technological society where technological inventions permeate our lives. Yet Technology takes up little of our attention. Cheek (2000) bemoans the fact that although Technology is so pervasive, it barely is part of the consciousness of most Americans, despite the fact that they interact with technological systems and artifacts every moment of their waking lives. He ascribes this partly to the marginalisation of Technology in the curriculum. The planners of C2005 appear to have attempted to satisfy two opposing approaches. On the one hand, Science and Technology are presented as two separate learning areas; on the other, the curriculum suggests an integrated approach, albeit in the intermediate phase of schooling.

If Science and Technology are closely linked and should be viewed in an integrated manner, the question arises why the two disciplines have become separated to the degree it has been up till fairly recently. The separation of Science and Technology has developed over time and this separation has led to confusion as it creates the impression that the two are distinct disciplines and neglects the close relationship between the two (Zuga 1996) The two disciplines are enmeshed in their own culture and this separation has been extended into schools. Traditionally the two have been taught separately. The two disciplines operate differently –Science is abstract and theoretical and Technology is seen as practical. Zuga (1996), however, argues that the link between the two is too strong to present them so distinctly.

The Science-Technology-Society approach to Science Education is an attempt to develop scientific literacy by making students aware of the impact of Science and Technology on society. Both the technology and science curricula include a Learning Outcome (LO3) which is aimed at developing an 'understanding of the interrelationships between Science, Technology ,society and the environment (DoE 2002,18). By integrating Science and Technology it may be easier for learners to understand the impact of Science on society and lends further justification for curriculum developers to suggest integration. The STS movement advocates scientific and technological literacy as it is believed that literate people would be sensitive to issues that affect society. Rubba (1991) believes this is our only hope for resolving environmental problems. C2005 assumes that LO3 would achieve this, but this requires learners to think holistically. To achieve this would require the ability to integrate disciplines successfully.

Fears that integration would have a negative impact on Science as it would lead to the watering-down of Science is probably the reason why integration is only suggested in the Intermediate Phase and only implied in the higher grades through Learning Outcome 3. Integration implies a fundamental change in the way Science is presented as advocated by Fensham (in Aikenhead,2003) from learning science, to learning through science and a more 'science for society' approach.

In summary, the literature strongly supports the integration of Science and Technology and provides justification for the decision taken by the designers of C2005. The purpose of this research is to determine if students are in fact capable of integrating Science and Technology effectively, given their grounding in these disciplines.

METHOD

The research is framed by an interpretive paradigm as we wanted to find out what students' understandings and interpretations are of an integrated science and technology approach. Information from biographical data was used to determine what the students' background knowledge of Science and Technology was when they enrolled for LAS 310. Qualitative data obtained from a questionnaire and interviews provided deeper understanding of students' ability to design integrated science/technology activities. By determining what students understand and how they design activities, we were able to evaluate whether the outcomes as set out in the module are realistic and reachable i.e. whether they are located within the ZFI.

Table 1 Methods of Data Collection

Instrument	Purpose
1. Information sheet	To obtain information with regard to their previous experience of Science and/or Technology
2. Questionnaire	To probe their understanding of what the course entails
3.Examination task Students were expected to design an integrated Science/Technology activity.	While the examination results were not used as data in this study, the tasks were used as a basis for the interview
4.Interviews 12 students were interviewed	Interviews focused on the following aspects Students' understanding of the design process as set out in LO1 of the Technology LA Students' understanding of the scientific process and the process skills associated with the process Did the examination task demonstrate the integration of the scientific and technological process? Students' understand of Learning Outcome 3 of both learning areas and how to incorporate this Learning Outcome in their teaching.

The examination task

The task required students to demonstrate an understanding of what a scientific investigation entails as opposed to solving a technological problem. This means a student could use the technological process to design something (eg a rain gauge) that could then be used to carry out a scientific investigation (eg measuring rainfall over a period of time). Alternatively a student could use a scientific investigation to make decisions as to what kind of structure should be designed (eg subjecting certain materials to a test for durability, making a decision based on the outcome and using a particular material to build a structure).

FINDINGS AND DISCUSSION

Students' background in Science and Technology

The first set of data gave us some indication of the background students who enrolled for the course had in Science and Technology. Table 2 shows the results.

Table 2. Students' background in Science and Technology

A	B	C	D	E	F
General science (Grade 9)	Physical Science or Biology (Grade 12)	Natural Science LA (B.Ed)	Technology LA (B.Ed)	Science and Technology LA (B.Ed)	No LA (B.Ed)
		24=Int/Snr 1=Found/Int	11= Int/Snr 1= Found/Int	All(3) Int/Snr	All (24)Found/ Int
40,6%	57,8%	39,2%	18,7%	4,6%	37,5%

The table shows that only 57,8% of these students who will be expected to teach an integrated Science/Technology course to grade 4-6 learners were involved in science learning up to grade 12 during their school years, while 40,6% only had science up to grade 9.

With regard to students selecting Science and/or Technology, there is a clear pattern, as most students who selected these learning areas were Intermediate /Senior Phase students (Columns C, D and E). The Intermediate/Senior Phase students' who did not select mathematics, were obliged to select Science or Technology in the B.Ed programme. Natural Science or Technology was not compulsory for those students who were registered for the

Foundation/ Intermediate phase (Columns C and D) and the table shows that only 2 of them did.

Key questions exploring students understanding of the course
Students were asked three questions. Table 3 shows their responses.

Table 3. Students' expectations of the course

Questions	**Responses**	
What do you expect to gain from this module?	How to integrate Science and Technology	13,3%
	More knowledge of both learning areas	30,6%
	More Science knowledge	13,3%
	More Technology knowledge	5,3%
	Improved teaching of both learning areas	25,5%
	How to teach science	5,3%
	Other	6,7%
Do you foresee any specific challenges?	Too little background in Science and Technology	7,8%
	Too little science knowledge	13%
	Too little technology knowledge	6,5%
	Concern about projects in Technology	13%
	Responses not directly related eg, concerns about time, examinations, group work, class size etc.	22%
	No Challenges	37,7%
Do you think science and technology can be integrated?	Yes	87,8%
	Not sure	5,4%
	No	6.8%

With regard to what students expect from the course, it is significant that only 13,3% of the students expected to learn how to integrate science and technology knowledge in their lessons. The majority of students expected to improve their science and/or technology knowledge (49,2%). They are fully aware of the gaps in their knowledge and understand the importance of improving their content knowledge. A significant percentage also expected the course to enable them to teach the Natural Science and Technology Learning Areas. This response may be interpreted as including the ability to integrate the disciplines of Science and Technology in lessons, but the fact that some students mention both learning areas and others specifically mention science, seems to indicate that the teaching strategies referred to do not include integration.

With regard to possible challenges, a significant number foresaw no challenges(37,7%) this is possibly due to the fact that their expectations of the course were merely to improve their content knowledge and therefore was not seen as a problem. Their concerns lay with their weak knowledge base in Science and /or Technology, as well as the technology design they were expected to produce. The fact that no students were concerned about integrating Science and Technology demonstrates how far this construct is removed from their experience.

When the question of integration was pertinently put to them, the majority agreed that it was possible. This is an expected response as the fact that integration is a possibility was brought to their attention. More significantly however, is the fact that a certain number of students (12,2%) was either adamant that, or unsure if integration of these disciplines was at all possible. This may of course point to the possibility that they had a limited understanding at that stage of what integration entailed.

Interviews

Students generally find it easier to understand the technology process. Those who selected Technology as a learning area were able to design a task using the technology process.

> R: Would you say Technology is easier, because you did it in your degree or is it generally easier than Science or is Science more challenging?
> S1: I enjoyed Technology because for me it was easier

They find the scientific process much more difficult. Even the students who selected Natural Science, had difficulty in understanding what the process entailed.

> S2: Science was a big challenge for me. To integrate was very difficult. To integrate something that I did not know with something I knew, was a big challenge.

They did not understand what was meant by a hypothesis and could not describe the scientific process.

R: Let's look at your exam task- Natural Science LO1-what was the problem statement you identified?
S3: Pause
R: Do you understand the question?
S3: Not really.
R: OK –if you expected the learners to conduct the investigation. What was this problem?
S3: I have no idea
R: But an investigation is more than this is it not? It's about asking a question, formulating a hypothesis …….
S3: We missed that completely I think
S4: Well where we were at fault- we thought that by just planning the investigation –you know the steps –we thought that was more Natural Science, but actually it wasn't-but I think we did not really grasp that concept related to gravity
R: yes, because you took something that was actually a technology exercise

The biggest problem appeared to be the fact that students had difficulty distinguishing between the technology design and the scientific process. For instance, a student who designed a birdfeeder saw the design of the bird feeder as satisfying both the Technology and Natural Science Assessment Standards. She could not conceptualise how to use this technology design to do a scientific investigation

Students who had difficulty distinguishing between the technological and scientific processes invariably had difficulty integrating the two learning areas as the scientific process was left out in their planning. The most significant difficulty was differentiating between the meaning of what is meant by a problem in the two disciplines. They tended to see a scientific 'problem' as a barrier, rather than a leading or investigative question and tended to interpret a problem in the way it was used in technology.

R: Lets go on to the second section –integration. With regards to your exam task- looking at LO 1 of the Natural Science LA. Obviously you have to identify a problem- what was the problem the learners would identify?
S7: OK – they needed to identify the measurement of rainfall- how can they in the classroom develop something to measure rainfall.
R: Was this a scientific problem or a technological problem?

> S7: Well it's a bit of both –you need your science knowledge- you need to know about rainfall. And the tech knowledge, you can't just measure rainfall –you need to make something.

It would appear that the Technology Learning Area as offered in the B.Ed programme is sufficient to give students the necessary grounding to design technology tasks. However, the Natural Science does not appear to be sufficient as students expressed their lack of confidence to plan investigations and this was supported in the interview where it was clear that they did not understand what was meant by a scientific investigation. This lack of understanding hampers their ability to integrate the two learning areas. Even students who elected to do both science and technology as learning areas, expressed their lack of confidence in planning scientific investigations.

None of the Foundation/ Intermediate Phase students interviewed had Technology in their course, while two had Natural Science. These students had particular difficulty integrating Science and Technology as they had limited knowledge of the Technology as well as the Natural science learning outcomes. They did not fully understand the technological process and had a very poor understanding of what a scientific investigation entailed.

> S8: So it was difficult because it is kind of new to me. Even though I did the whole module, it was difficult for me. The integration was difficult to grasp and everyone had a problem there.

The interviews revealed serious shortcomings in students understanding of the technological and scientific processes respectively and these shortcomings made it difficult for them to design integrated activities.

CONCLUSION

The findings show that students who intend teaching in the Grades 4 to 9 generally have a poor grounding in Learning Areas such as Science and Technology. In the B.Ed programme described in this study, students prefer to select learning areas other than Science or Technology. It is only when they have no choice that they select one or the other; seldom both. Out of a cohort of 64 students only 3 selected both learning areas.

Given the reluctance of students to engage with these two learning areas, expecting them to engage in the integration of the two, is too difficult for the vast majority of students in this module. The ZFI for these students implies better preparation in the basic learning areas with regard to content as well as teaching strategies. Expecting them to integrate the learning areas is unrealistic and not feasible. While the designers of the B.Ed curriculum at this institution attempted to align the curriculum with C2005, this has resulted in the inclusion of a module that is impractical as most students benefit very little from it. The argument is that poor performance of students is due to the fact that they are expected to demonstrate the ability to transfer concepts between Science and Technology, as well as the integration of science and technology processes in lesson planning, while they lack the basic knowledge in Science and Technology. This is not realistic or achievable The boundry of a ZFI in this context needs to be redefined to include only Technology and Science, rather than a module that requires students to integrate Science and Technology in lessons. There is no opportunity for these students to scaffold their knowledge as they do not have the basic science and technology knowledge on which to build. Students who lack sufficient knowledge of Science or Technology may find it very difficult to interpret the learning outcomes of either learning area in such a way that would enable them to integrate the two effectively.

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Appendix 1

Learning Area Studies 310: Examination - June

1. Examination dates: 25, 26, 27 May

- Indicate on the list on which day you prefer to do your presentation.
- It is compulsory to be present for all presentations **on the day** you present as you will be requested to assess your peers as they present

2. A maximum of two people per presentation.

- You will be allocated 15 minutes for your presentation.
- Both you and your partner must participate in the presentation.

3. TASK

- Select a topic from the Natural Science Intermediate Phase Curriculum or the Technology Intermediate Curriculum. Choose a topic that you **HAVE NOT** covered in class.
- Indicate the Grade that your activity is aimed at.
- The RNCS for Natural Science discusses Learning Outcome 1 on page 8 where it refers to four kinds of practical problems that learners may investigate. One category is problems of making.
- Select an activity that allows learners to put their mind to a 'problem of making' that will require them to construct something. This also encompasses Learning Outcome 1 of Technology: "The learner will be able to apply technological processes and skills ethically and responsibly using appropriate information and communication technology" (DoE, 2002, p.31)
- Your activity must engage learners in a scientific investigation which involves Learning Outcome 1 of Natural Science: "The learner will be able to act confidently on curiosity about Natural phenomena, and to investigate relationships and solve problems in scientific, technological and environmental contexts." (DoE, 2002, p.16)
- Build an example of a construction you would expect learners to make.
- Prepare a poster indicating what the chosen activity is. Your poster should clearly display the Learning Outcomes and Assessment Standards that your activity addresses.
- Give an explanation of how the Technology Learning Area Learning Outcomes and Assessment Standards may be attained when learners make the construction.
- Give an explanation of which Natural Science Learning Outcomes may be achieved through this activity and how they are achieved.
- Explain exactly how the selected Assessment Standards may be attained.

STUDENT-TEACHERS EXPLAINING ACIDIFICATION IN THREE DIFFERENT SCALES: A CASE STUDY

Artemisia Stoumpa
University of Athens, Hellas
artemis.stoumpa@gmail.com

Anthimos Chalkidis
University of Athens, Hellas
achalkid@gmail.com

Constantine Skordoulis
University of Athens, Hellas
kskordul@primedu.uoa.gr

ABSTRACT

In the context of Environmental Science in Education students study phenomena and problems occurring on a time and space scale which is too large to be immediately perceived. Such occurrences are interpreted through processes and changes taking place in macro scale, while the macro scale processes themselves are interpreted by means of models of systems and processes at cellular and atomic molecular scales – micro scale. In order for us to analyze the way student-teachers link the three levels of understanding (micro, macro and large scale) so that they will be able to explain the environmental phenomena and problems, we designed a didactic intervention addressing the issue of acid rain interaction with the natural environment on all the three scales. The students' pre-tests post-tests and worksheets analysis showed that, although the students were not eager to use models of the micro scale in their explanations, the contact with the models and processes on micro scale through educational software rendered the majority of them able to correlate the macro with large-scale changes in their explanations.

Keywords: *Environmental Science, student-teachers, acid rain*

INTRODUCTION

Recently, the need for introducing the environmental dimension of science in education has become prominent (Gough, 2002; Edelson, 2007). Usually, in the context of Environmental Science in Education students study the natural dimension of environmental systems, which are complex socio-ecological systems. This study concerns phenomena and problems such as the hole in the ozone layer, acid rain and the greenhouse enhancement effect, that take place on a very large scale of time and space (Mitchell, 1989; Tett *et al,* 2000; WMO, 2007; Akselsson *et al,* 2003), and, therefore, can not be fully perceived. These phenomena can only be conceived and interpreted via macro-scale changes and processes that can be perceived directly (ranging approximately from 1mm to 1km). Macroscopic systems and processes are explained "using models of systems and processes that are too small to see, at the cellular and atomic-molecular scale", micro scale (Anderson, 2007).

The objective of this study is to examine the way student-teachers link the three levels of understanding of the natural world (micro, macro, large) when interpreting environmental phenomena and problems. In particular, this is a case study examining student-teachers ability to perceive and explain the interaction of acid rain with the natural environment. The fundamental factor of this interaction is the acid / weathered bedrock reaction when acid rain penetrates the soil. When soil buffering capacity is strong (calcareous subsoil) the weathered rock (soil minerals and weathered bedrock) reacts with acidic water beneath the soil and neutralizes the acidity, thus protecting aquatic and terrestrial ecosystems. When soil lacks buffering capacity (siliceous subsoil) ecosystems are, in the long run, strongly affected (JCE, 2003). The occurring reaction is perceived at macro level but is explained at a molecular level (micro scale) and its results can be seen in ecosystems in a time range of some decades (large scale).

METHODOLOGY

The research questions of this article are:
1. In which way students describe and explain the reaction that underlies the different effect of acid rain on different ecosystems?
2. Which scales are used by the students when they describe and explain the acid rain effect on the natural environment?
3. In which way the students' contact with models and processes of micro scale influences their ability to explain the phenomenon in macro and large scale?

The research described here was conducted in a class of 59 pre-service teachers, students of the National and Kapodistrian University of Athens who attended the one-semester course "Natural and Environmental Sciences – a Laboratory approach" in 2008-2009. In the above mentioned course, students study modern environmental problems, acid rain being one of them. Acid rain is included in the course curriculum since Athens city has been faced with a serious acid pollution problem resulting in the permanent degradation of some of the most important monuments of its cultural legacy.

Nowadays, as a result of intense effort and environmental measures taken, a reduction of the acid pollution in Athens has been achieved, although acid pollutants have not been entirely eliminated (Adamopoulos *et al,* 2009). Although the main concern of our study is the acid rain / natural environment interaction, acid rain / human environment interaction is important for the course curriculum. Therefore, we constructed a didactical intervention in which, without underestimating the part of study concerning the acid rain effects on monuments, the study of acid rain / natural environment interaction is appropriately integrated and emphasized in the didactical activities.

The didactical intervention:

Before the actual didactical intervention a pre-test was filled in by the students. This pre-test contained both multiple-choice questions in which justification was asked for their choices, as well as open-ended questions. This pre-test was the first source from which we drew upon our first data collection for our research. More specifically, the students' answers in 7 key questions of this questionnaire comprised the 1st data collection.

Initially, students approached the acid rain / environment interaction in macro scale in the wet lab where they tried the way in which acids interact with siliceous and calcareous materials in order to elaborate on and answer the following questions: 1)How does the kind of the stone used as building material affect the vulnerability of constructions in case of acid pollution attack? 2) Is it possible that the underlying bedrock of an ecosystem can affect its interaction with acid rain and in what way? Students were given worksheets in which they concisely recorded the experiments they designed and executed, and answered the two questions according to their findings. The answers in the second question comprised our second data collection.

Afterwards, in the computer laboratory students, in groups of two, investigated the way acid pollution affects different semi-natural environments (large-scale approach) with the use of educational software. Approximately half of the groups built a virtual semi-natural landscape with underlying siliceous bedrock. The landscape consisted of a forest of various trees near a lake and an industry on the other side of the lake. Near the lake they also built a statue made of indigenous material (granite). The remaining groups built a similar virtual landscape but with calcareous bedrock and erected a statue from marble which was abundant in their local landscape. All groups filled in worksheets in which they recorded the changes that they observed occurring in the landscape under the influence of acid pollution. That means, changes to the statues' condition, changes in the life of ecosystems and the physicochemical properties of the abiotic factors of ecosystems such as soil pH, pH of rain clouds and fog, as well as the lake water pH. In addition, students were able to record some other physicochemical properties of abiotic factors such as detection of air pollutants, the presence of nutrients or poisons in the soil -depending on which of those properties they considered important for the study of the evolution of the landscape.

When the groups finished the exploration of the virtual landscapes, all of them discussed their findings together. They compared the different evolutions of their virtual landscapes, and they talked about their observations. Finally, they recorded their opinion on how acid rain affects the environment. These recordings are the third collection of data (texts) to be analyzed in order for us to answer our research questions.

The third stage of our didactical intervention took place in the computer laboratory again using the same educational software. Students, again teamed up in groups of two, investigated the nature of acid rain, and the importance of acid / rock reaction at the microscopic scale. More precisely, they built virtual landscapes (similar to the above mentioned) where they "zoomed in to the micro scale dimension" of the rain falling in order to "see" the acids dissociation and have a clearer idea of the concept of acidity and, consequently, of the meaning of acid rain. In order to "see" the deeper explanation that chemistry can offer on acid / rock interaction, all of them built virtual landscapes resting on calcareous bedrocks, with marble statues. Students zoomed in the microscopic scale of this reaction taking place on the statue material, an interaction that at macroscopic level is interpreted as monument erosion. They also studied the same reaction as it occurred in weathered bedrock (stones and minerals) as the acidic waters flowed in the soil, leading to neutralization and therefore, to ecosystems protection. In the last part, of this stage of the didactic approach, all groups discussed the way acid rain affected the city of Athens, which is founded on calcareous bedrocks, and wrote down their own conclusions. These last recordings comprised our 4rth data collection. After the didactic intervention, students completed post-tests. The post-tests were not identical to the pre-tests, but all questions corresponded to the pre-test questions. The students' answers in 7 key questions of the post-test, corresponding to the 7 key questions of the pre-test, comprised the 5th data collection. These pre and post-test key questions, gave students the opportunity to describe in detail how they perceived the acid rain / environment interaction. Four of these questions (1st set of questions) encouraged students to describe this interaction without introducing the "type of underlying rock" factor. The other three (2nd set of questions) encouraged students to describe this interaction by introducing this factor, thus providing students with the opportunity to express their opinion whether and how the rock may affect the impact of acid rain on ecosystems.

As far as these two sets of questions are concerned, a first analysis showed that in the pre-test students answered the two sets of questions in a different way. So, when analyzing pre-tests, we analyzed the two sets of answers separately. However, in the post-tests students answered all 7 questions in a way that their answers were complementary to each other, thus avoiding repetitions. The answers to the post-test 7 key questions were analyzed as a whole.

The fact that there were more than one questions concerning the same subject in the tests gave us the chance to compare the students' answers -in the varied questions- so that we would be able to interpret as accurately as possible the students' recordings. Thus, we accomplished internal validity which, obviously, is not identified with the strict objective validity of quantitative research (Winter, 2000; Velentzas, 2010, p. 183).

Similarly, in the worksheets the key questions were themselves part of a wider recording context in case the respective answers seemed controversial or difficult to be classified. In such case they could be clarified by means of students' recordings in relevant parts of the worksheet. Moreover, the fact that both the tests and the worksheets were filled in the context of the didactical intervention in real class conditions increased the data validity since the students were motivated to give veracious and clear answers.

Defining categories and subcategories for data quantification

In order to analyze our data (students' answers), we referred to previous researches of science didactics examining the way students describe and explain phenomena at different scales. In particular, we focused on the researches in which the phenomena explanation is based on chemical or biochemical reactions since this is the central theme of our case study (Mohan *et al;* Anderson, 2007; Ahtee & Varjola, 1998; Barker, 1999; Hesse & Anderson, 1992; Ardac & Akaygun, 2005; Solsona *et al,* 2003). Finally, we decided to perch on the study of Solsona *et al* (2003) in which senior high school students were categorized according to the way they described the concept of chemical change, a concept that was interpreted at two scales (micro and macro) in school science. This decision was taken because in that research the data were in form of texts, and our data are mainly texts too. A second reason for this decision was the fact that the way students interrelate processes and changes described at the macroscopic scale to the processes described at the microscopic scale, plays a key role in the data analysis in this research. This is something of great importance in our research too. The initial (Solsona's and her colleagues') categories were modified and expanded so that our data could be displayed more precisely, and the large scale which is absent from traditional Chemistry curriculum but is crucial in Environmental Science in Education could be included. Below we describe the categories and subcategories as they solidified and finally turned out to be a tool with which we were able to quantify our data.

1st category: "Levels". In this research, we considered as highest performance on the part of the students, their ability to describe the acid rain / natural environment interaction as following: At large-scale level we expected them to describe the different effects of acid rain on terrestrial and aquatic ecosystems depending on how the subsoil allowed or prevented the soil and water acidification. At the macroscopic-scale level we expected them to interpret the different effects of acid rain on surface waters and soils through acid / rock chemical interaction.

Finally, we expected them to use models of the microcosm to explain this interaction (microscopic-scale level). For this category the following subcategories were distinguished:

- "Non reference to interaction". When students don't describe processes or changes at all. This is depicted as "LØ" in tables and charts.
- "Large-scale level description". When students describe how acid rain affects abiotic factors and life in ecosystems. There may be different versions of their descriptions regarding how detailed the latter may be, which properties of abiotic factors the students focus on, and whether they describe both abiotic factors and their impact on life or only one of the two. This subcategory is depicted as "La" in tables and charts.

- “Macro-scale level description”. When students in order to describe how the acid rain affects the natural environment, they only describe the acidic water / stone interaction. This subcategory is depicted as “Ma” in tables and charts.
- “Description at Macro and Large scale levels which are not successfully interrelated”. It is a combination of the two above mentioned levels, macro and large, but without establishing the correct interrelation between the macroscopic and large levels. That means that macro-scale processes are described in such a way that they are inadequate to explain and justify what is described in large scale. This subcategory is depicted as “Ma#La” in tables and charts.
- “Description at Macro and Large scale levels which are successfully interrelated”._It is the correct combination between the macroscopic and large levels. This means that in their recordings, students describe the outcome they anticipate (or observe) of acid rain affecting ecosystems, and they explain their opinion based on the different way acidic water interacts with different kinds of rocks. This subcategory is depicted as “Rel(Ma,La)” in tables and charts
- “Description at Micro, Macro and Large scale levels which are successfully interrelated”. It is the perfect and thorough way of describing the environmental phenomena and problems. This means that recordings classified in this subcategory, not only explain the different ways acid rain interacts with seemingly similar ecosystems through acid /rock interaction, but also explain this interaction using entities and systems of the microcosm. In order for a text to be classified in this category, it is not sufficient to contain references to some entities of the microcosm, but should be obvious in the texts why these entities are important. This means that the microcosmic entities and processes mentioned must substantially contribute to the explanation of the observed changes at the macro and large scales. This subcategory is depicted as Rel(Mi,Ma,La) in tables and charts

2nd category: “kind of change”. Through this category we are trying to investigate how students understand the acidic water interaction with the natural environment in the two lower levels, namely microscopic and macroscopic level. As mentioned above, this interaction is defined by the acidic water / rock reaction in the soil, ie when this reaction is strong it buffers the acidity of abiotic factors (soil and water). Consequently, we are investigating how students understand and describe this very chemical reaction. In this category we distinguish the following subcategories.

- “No change statements given”._This subcategory is depicted as “ChØ” in tables and charts
- “Erosion”. When students refer to stone erosion, or stone plasterization by the acidic water percolating the soil, without giving more information about changes in properties or substances. This subcategory is depicted as “Ers” in tables and charts
- “Physical Change / Change in Properties”. When students describe the change of properties (acidity, calcium and aluminum concentration) resulting from the acidic water / stone (in the soil) interaction. Some of the texts belonging to this subcategory describe the interaction as mixing, absorption, dissolution, while others regard it as reaction. However, even in the latter texts, it is not clear that the students have fully understood the nature of the reaction. This subcategory is depicted as “Ph/Pr” in tables and charts.
- “Substance change”. When students, having fully understood the reaction, describe precisely the acid/stone interaction as formation of new substances from the initial substances which have practically disappeared. As the new substances’ properties are different from the initial ones, the reaction results in the change of properties in the reacting system. This subcategory is depicted as “Sub” in tables and charts.

3rd category: "Effects on Ecosystems". Through this category, we are trying to investigate how students understand the acidic water interaction with the natural environment at the large level, ie at the level where the evolution of entire ecosystems is observed. These changes are exactly the subject of environmental science, and it is because we need to predict and explain them that we study the changes at the lower two levels (scales). In this category we distinguish the following subcategories.

- "No effect statements given / undefined"_When students select "don't know" in multiple-choice questions, do not answer at all, or give an answer not relevant to the question. This subcategory is depicted as "NA" in tables and charts.
- "All Vulnerable"._When students describe damage that occurs in terrestrial and aquatic ecosystems but without considering the possibility of any factor in the ecosystems playing an important role in protecting the ecosystems from acid pollution.
- "Calcareous Vulnerable"_When students express the view that ecosystems with underlying calcareous subsoil are more vulnerable to acid rain attack than similar ecosystems with underlying siliceous subsoil.
- "Differentiated effects" When students consider that the different interaction of acid rain with the different rock types may be important to the ecosystems, but they also consider that the strong interaction with the calcareous rock results in both positive and negative consequences to ecosystems founded on such subsoils.
- "Calcareous Resistant" When students express the view that ecosystems lying on calcareous subsoil are more durable to acid rain attack than similar ecosystems lying on siliceous subsoil. This last view is the "correct approach" to the acid rain / natural environment interaction phenomenon.

RESULTS

Analyzing our data by means of the set of categories and subcategories described above, we derived the quantified results that are depicted on the tables that follow.

Table 1: quantification of 1st data collection, 1st set of questions

Effects on Ecosystems	Levels	kind of change	instances
NA	LØ	ChØ	1
	La	ChØ	1
All Vulnerable	LØ	ChØ	6
	La	ChØ	51

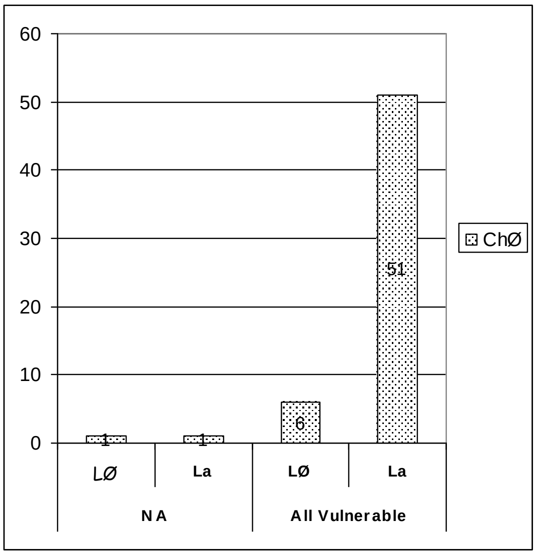

Chart 1: 1st data collection, 1st set of questions

Table 2: quantification of 1st data collection, 2nd set of questions

Effects on Ecosystems	Levels	kind of change	instances
NA	LØ	ChØ	6
	Ma	Ers	1
All Vulnerable	LØ	ChØ	1
	La	ChØ	1
Calcareous Vulnerable	LØ	ChØ	22
	Ma	Ers	22
	Rel(Ma,La)	Ers	3
Calcareous Resistant	LØ	ChØ	2
	Rel(Ma,La)	Ph/Pr	1

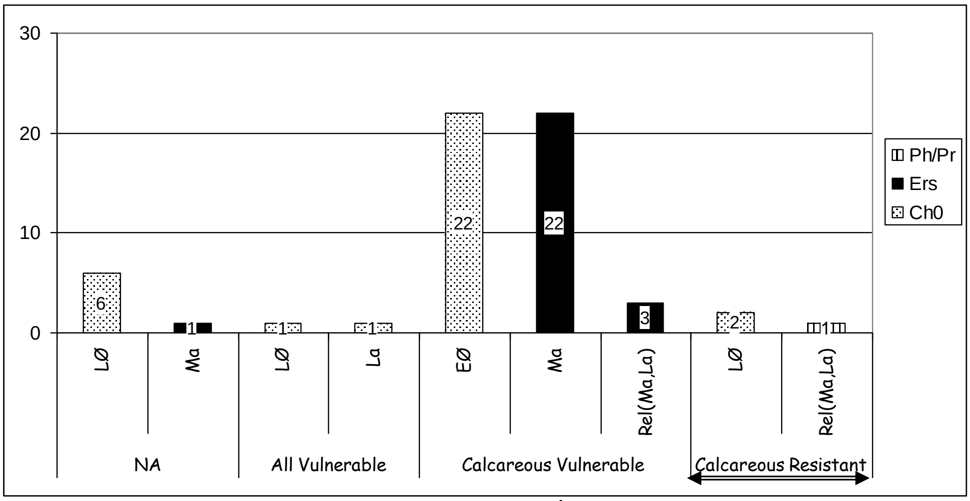

Chart 2: 1st data collection, 2nd set of questions

In the pre-tests students preferred to give large and macro-scale descriptions but without linking large scale changes described in the first set of questions to macro scale processes described in the second set of questions. So, in the first set of questions, the large majority (51 subjects) described the consequences that –in their view- acid rain had on ecosystems' abiotic factors (surface water acidification, soil erosion), but mainly on ecosystems' biota (trees and aquatic organisms). However, they didn't refer to the acidic water / rock interaction and, therefore, didn't distinguish between ecosystems more resistant or vulnerable to acid attack. In contrast, in the second set of questions, the majority of them (47 out of 59) thought that ecosystems resting on calcareous foundation were more vulnerable to acid rain attack. Approximately half of them justified their view by referring to their knowledge about acid rain / calcareous stones strong interaction. Therefore, they deduced that the rock vulnerability was somehow transferred to the ecosystem but without describing which factors of the ecosystem were influenced and in what way. Only 3 out of 47 referred to specific effects on abiotic factors (soil erosion, collapse of the terrestrial ecosystem). The other 22 did not justify their view at all.

Table 3: quantification of 2st data collection

Effects on Ecosystems	Levels	kind of change	instances
NA	LØ	ChØ	4
All Vulnerable	Ma	Ers	1
Calcareous Vulnerable	Ma	Ers	20
	Rel(Ma,La)	Ers	24
Differentiating effects	Rel(Ma,La)	Ph/Pr	2
Calcareous Resistant	Ma	Ph/Pr	3
	Rel(Ma,La)	Ers	1
		Ph/Pr	4

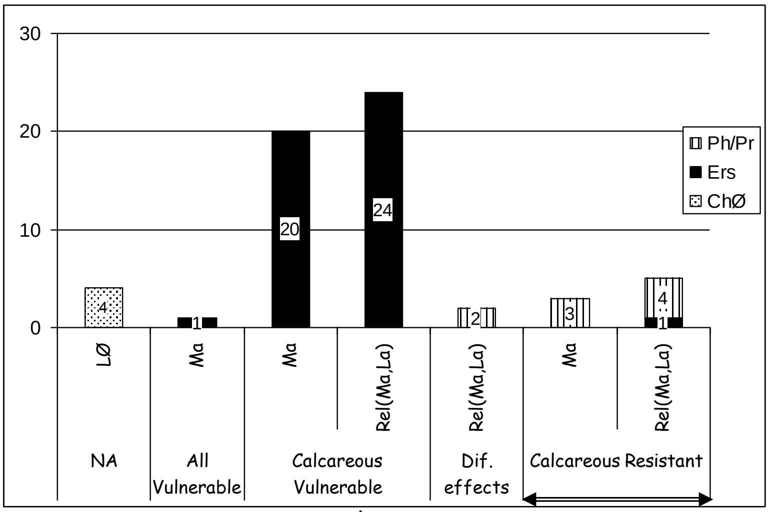

Chart 3: 2nd data collection

In the wet lab they tried different rock types interaction with acidic solutions and they confirmed their initial notion about the acid / calcareous stone strong reaction. From the experiment descriptions in their worksheets it can be derived that, although the vast majority of them measured the pH increase this interaction entailed, they persisted focusing on the destructive side of the reaction. Consequently, they deduced that this interaction led to natural environment erosion (which is wrong). Half of them suggested soil collapse, thus interrelating macro and large scales. However, a small part of the sample (9 subjects) begun to suspect the impact the pH change might have on ecosystems.

Table 4: quantification of 3rd data collection

Effects on Ecosystems	Levels	kind of change	instances
NA	LØ	ChØ	2
	La	ChØ	1
	Rel(Ma,La)	Ph/Pr	2
Differentiating effects	Rel(Ma,La)	Ers	2
Calcareous Resistant	La	ChØ	30
	Ma # La	Ers	3
	Rel(Ma,La)	Ph/Pr	19

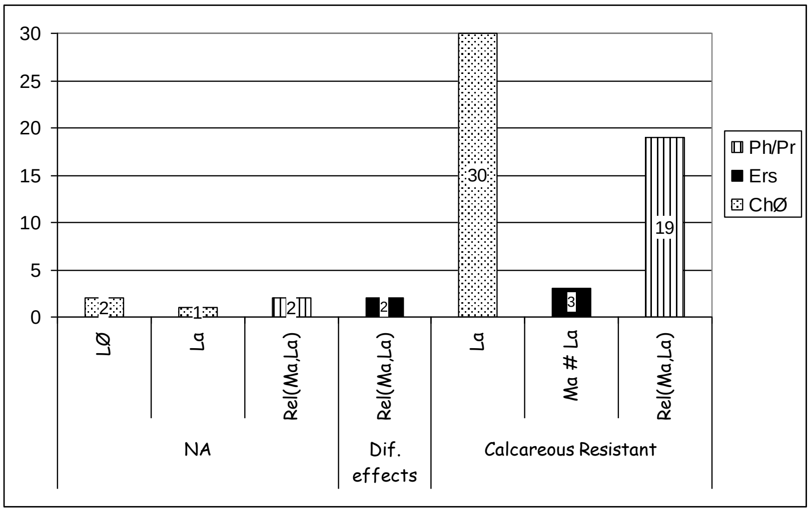

Chart 4: 3nd data collection

When, through the software, students approached the problem at the large-scale domain (ecosystems' long term alteration), the large majority described it at this scale correctly. Moreover, a remarkable part of the sample (19 subjects) were able to interpret the large-scale phenomena (different acid rain effects on, at first sight, similar ecosystems) by macro-scale processes, more specifically by the acid /stone interaction as acidic water percolated the soil. They described this interaction as a change in properties - mainly in acidity.

Table 5: quantification of 4th data collection

Effects on Ecosystems	Levels	kind of change	instances
Calcareous Vulnerable	La	ChØ	1
	Rel(Ma,La)	Ers	2
Differentiating effects	La	ChØ	2
	Rel(Ma,La)	Ers	2
Calcareous Resistant	La	ChØ	9
	Ma # La	Ers	2
	Rel(Ma,La)	Ph/Pr	20
		Sub	13
	Rel(Mi,Ma,La)	Sub	8

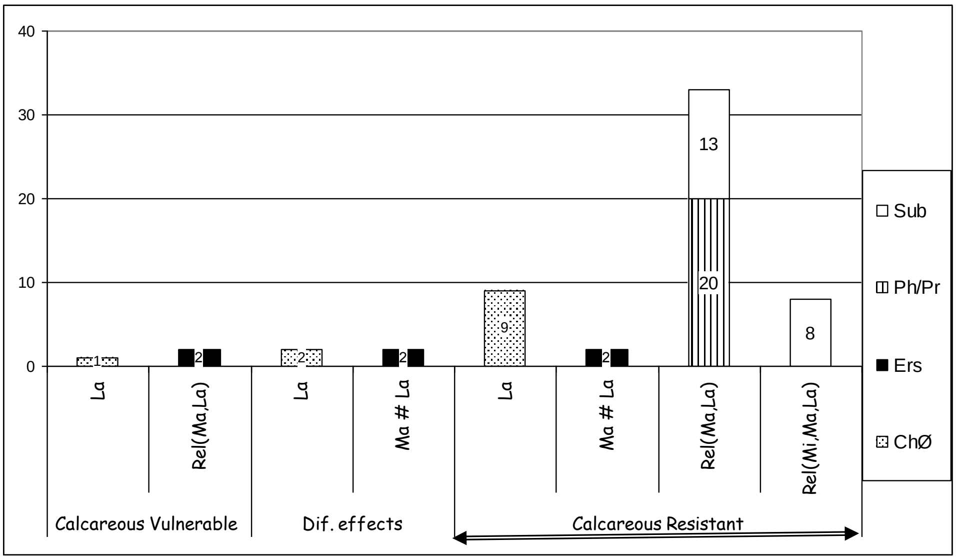

Chart 5: 4th data collection

When students, through the software, encountered micro scale systems and models they seemed to satisfactorily comprehend the chemical reaction and its significance to the ecosystem. Approximately one third of the sample described the reaction accurately as being a process of disappearance of some substances (the strong acid being among them) and a formation of new ones with different properties. One third of the sample described the reaction as a change in properties (mainly in acidity) without clearly defining this reaction. These two parts of our sample successfully explained what occurred at large scale through macro scale processes. However, only a small part of the sample (approximately 1/10), correlated the three scales (micro macro and large).

Finally, students described acid rain / natural environment interaction in a similar way in the post-tests as depicted in the following table and chart.

Table 6: quantification of 5th data collection

Effects on Ecosystems	Levels	kind of change	instances
Calcareous Vulnerable	La	ChØ	2
	Ma	Ers	1
	Rel(Ma,La)	Ers	8
		Ph/Pr	1
Differentiating effects	La	ChØ	1
	Rel(Ma,La)	Ph/Pr	2
Calcareous Resistant	La	ChØ	6
	Ma # La	Ers	2
	Rel(Ma,La)	Ers	1
		Ph/Pr	20
		Sub	9
	Rel(Mi,Ma,La)	Sub	6

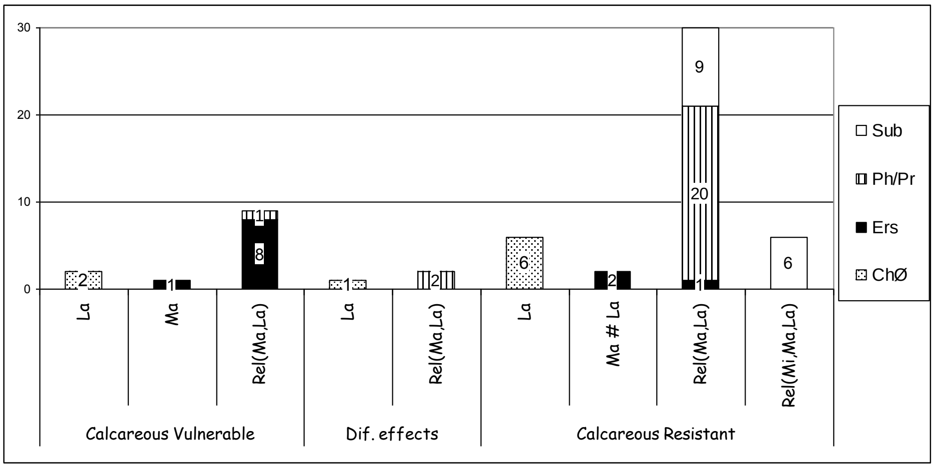

Chart 6: 5th data collection

CONCLUSIONS

In order to answer the research questions of the current study we had to observe and interpret the charts given in the results section. As far as the scales used by the students when they described and explained the acid rain effect on the natural environment are concerned, we noted the following: In the two first stages of the didactic intervention, students tended to describe the changes occurring in ecosystems (large scale), or macro-scale processes depending on the level on which the particular stage focused. A relatively small part of the sample tried to predict or explain the large-scale changes using deductions from the macro-scale ones. However, this did not occur in the third stage of the didactic approach which focused on micro-scale. That means that they did not incorporate microcosmic systems, entities and processes in their descriptions although microcosm was at play in this stage. However, it is worth mentioning that a larger part of them correctly interrelated changes and processes at the two higher levels, i.e. they correctly explained the way local bedrock offered (or did not offer) adequate protection to ecosystems from acid rain attack.

As far as the way in which students described and explained the acid / stone reaction is concerned, we noted that, initially, students (in the pre-tests and the first worksheets) described this reaction rather superficially, as damage to the stones. When the students interacted with the virtual landscape for the first time, they tried to explain their observations which, judging from their descriptions in the pre-test and the first worksheets, contradicted their initial views. Therefore, they began to describe the acid / rock interaction more precisely, by focusing on the properties changes this interaction resulted in. Finally, students' interaction with the virtual representation of the microcosm in the computer lab played a key role in the understanding of the very nature of this reaction.

In conclusion, we could say that it was difficult for the majority of the students to use micro scale systems, models and processes in their explanations. Their interaction with the micro scale world helped them to enhance their understanding of the chemical reaction, and this enabled them to associate macro scale processes with large-scale phenomena.

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THE RELATIONSHIP BETWEEN STUDENT LEISURE ACTIVITIES AND DEVELOPMENT OF HIGHER COGNITIVE LEVELS

Andreja Špernjak

Faculty of Natural Sciences and Mathematics,
Department of Biology – Didactics of Biology,
University of Maribor, Slovenia

email: andreja.spernjak@uni.mb.si

Andrej Šorgo

Faculty of Natural Sciences and Mathematics,
Department of Biology – Didactics of Biology,
University of Maribor, Slovenia

email: andrej.sorgo@uni-mb.si

ABSTRACT

In Science teaching, laboratory work is recognized as one of the cornerstones. It can be successfully done with different methods of laboratory work. A previous research study of the influence on students´ knowledge of three different laboratory methods proved the connection between students´ leisure activities and better cognitive results for students. A group of 198 students of both genders from lower secondary school in Slovenia were chosen. These students, aged between 11 and 15 (5th to 9th grade), performed three Biology laboratory exercises (Activity of yeast, Gas exchange in breathing, Heart rate) as classic, computer-supported and virtual experiments. By using a pre-test and a post-test, we established the level of knowledge acquired in each exercise. With a questionnaire about leisure activities, we discovered that one of the most popular leisure activities, besides hanging out with friends, watching TV or listening to music, was playing on the computer; however, this did not contribute to higher levels of cognitive knowledge among students, neither did different laboratory methods. The most important factor leading to high cognitive levels of knowledge is students´ pre-knowledge.

Keywords: *Computer-supported laboratory, high cognitive levels, ICT, laboratory work, leisure, simulations*

INTRODUCTION

One of the active learning methods in Biology is laboratory work. With laboratory exercises and experimental work, we can achieve an understanding of many natural processes and empirical goals (Eschenhagen et al, 1998) which are less practicable or even unattainable with other education methods (Šorgo, 2007). With laboratory work students are actively included in the education process; they can create the process and in this way they can absorb more information for quality creation of knowledge (Luneta et al, 2007; Šorgo and Špernjak, 2007). Students in primary and secondary school (Šorgo and Špernjak, 2007) have a desire for active, creative and up-to-date laboratory work. Such laboratory work need not be limited to classic achievement; it can be strengthened with the application of information communication technology (ICT), where students, besides hand skills, can also develop computer competences (Špernjak and Šorgo, 2009). However, ICT in schools is mostly used for document creation, collecting information, for various methods of communication, or for using multimedia or virtual and real design biology laboratory work (Rogers and Wild, 1994; Strømme, 1998).

Higher education laboratory exercises have the potential not only to help students confirm theoretical knowledge, elaborate on it, and place it into a meaningful context, but also to help them learn scientific methodology and cultivate practical skills (Winberg and Berg, 2007). This is important not just for higher education but for all educational system. At the primary education level, the computer can be used on three different levels: for ‘basic computer skills’, ‘as an informational tool’, and ‘as a learning tool’ (Tondeur et al, 2007). Computers as a learning tool can be used in the laboratory for virtual or computer-supported laboratory work (CSL). With CSL, we have real results; conversely with virtual laboratory and computer simulation, the results are unreal (Kocijančič and O'Sullivan, 2004). In previous research we established that CSL and computer simulation can be included in biology laboratory work in primary school (Šorgo and Špernjak, 2007; Špernjak and Šorgo, 2009a). The major obstacles to incorporating CSL and computer simulation in primary schools are the teachers (Špernjak et al, 2009).

Yet the usage of ICT in Slovenian schools outside of specialized subjects like Computer Science or Informatics is welcomed but not obligatory for teachers. In existing teaching practice there exists an asymmetry with the expectations of students, who expect the teaching of biology to involve a mixture of interesting, multimedia-supported lectures with frequent laboratory and field work. In reality they most often get direct instruction intended to cover the textbook content in detail, with success on final examinations as the ultimate goal of education (Šorgo and Špernjak, 2007).

Unquestionably, ICT has had an impact on the quality and quantity of teaching, learning, and research in teachers’ and principals’ education (Moradi, 2009). Using ICT in schools can certainly offer interesting, topical and useful experience in education for both students and teachers. Graff (2003) and Mikropoulos et al (2003) claimed that students using ICT display effective mental processes and are more creative (Wheeler, 2002). The level of student knowledge is higher when using ICT than when using traditional educational techniques (Selinger, 2004), and students develop more key competences at the same time (Špernjak and Šorgo, 2009). Despite all the positive results of using ICT, up-to date technology should never replace teachers. Instead ICT should be a useful aid in education. We must seek the precise ratio between traditional ways of teaching and incorporation of ICT into education (Kubiatko and Haláková, 2009).

Computer usage in students´ leisure time

Research on children’s and youths’ use of technology in domestic settings is a growing field (Facer et al., 2001; Livingstone, 2003). One of reason is the growing cheapness and attainability of ICT equipment. In Slovenia there are more home computers every year. In 2003, 55 % of households owned computers, and in 2007 more than 66 % of Slovenian households had computers at home. Homes with children are better equipped with ICT than households without children. In 2007, as much as 77 % of households with children had access to the internet, compared to only 48 % of households without children (http://www.stat.si). Some researchers found that students use the home computers for different purposes than in schools (van Braak and Kavadias, 2005; Kerawalla and Crook, 2002; Livingstone, 2002; Meredyth et al., 1999; Ruthven et al., 2005; Selwyn, 1998; Somekh et al., 2002). One reason involves differing student interests, while computers in homes or in leisure clubs are more technologically advanced and offer a greater range of activities than those found in the normal classroom (Mumtaz, 2001).
To establish whether students of lower secondary schools who use computers during their leisure time develop higher levels of knowledge is one goal of our research. The other goals are to find the relation between students´ leisure-time intellectual activities (playing on the

computer, reading books, watching TV and studying school subjects) and the development of higher cognitive levels of knowledge.

Results will be targeted towards the development of a new generation of tested experiments and laboratory work to help teachers introduce active methods of teaching into their daily routine and the development of experiments to connect students' leisure time with school subjects.

METHODS

The pilot research was performed during summer school in 2008, with 198 students between 11 and 15 years of age. The fourteen-day summer school was performed on Krk, the largest Croatian island. Although the students were at the seaside, during the most intense heat of the day (between 1-3 p.m.), we arranged various activities. One of these was testing three different methods of Biology laboratory work. We used a pedagogical experiment with a questionnaire, a pre-test and a post-test.

In the test group were 25 (12.6 %) students in fifth grade, 33 (16.7 %) students in sixth grade, 52 (26.3 %) in seventh grade, 52 (26.3 %) in eighth grade and 35 (17.7 %) students in ninth grade. One (0.4 %) student left a field in the questionnaire blank, so we did not include this response in our analysis. To test the suitability of computer-based real and virtual laboratory, and to examine the differences among various styles of laboratory work, we prepared triplets of laboratory exercises. Each laboratory exercise in a triplet was prepared as classic laboratory work, computer-supported (real) laboratory work and interactive virtual laboratory work (computer simulations). In such a way, results were collected as 3x3 matrixes, which enabled us to search for differences between groups. Initially, we chose a well known and easy to perform laboratory exercise from current school practice. In the second phase this was adapted for computerized laboratory exercises. Vernier's interface, sensors and software (http://www.vernier.com) were used, but other acquisition systems would work as well. Interactive simulations were programmed in Microsoft's Visual Basic 6.0. Every simulation is a self-standing, auto-executive programme. The data obtained from computerized laboratory work were used to produce realistic graphs in interactive simulations developed for the purpose of the research.

The quality of knowledge produced by each method of laboratory work was tested by a pre-test and an equal post-test. For the pre-test, students received a questionnaire, where they ranked ten given activities from 1 to 10 according to their importance during the student´s leisure time. For each activity, they had to circle how much time per day they spent on it.

Description of laboratory exercises

Activity of yeast
This exercise is a standard one on account of its safety, the availability of materials and its potential for use at different points and contexts (rising of bread, fermentation, enzymatic activity, etc.) in teaching. The effect of temperature on the activity of yeast is examined. The speed of production of carbon dioxide is measured. In real experiments (both classic and computerized) a suspension of yeast obtained in a local store was prepared. A spoonful of plain sugar was added to the suspension. The suspension was divided into three bottles and put into water baths at different temperatures. Ice cubes were added to the first one, the second one stayed at room temperature, and the third was warmed to a temperature between 35 and 40°C. In the "classic" variant the rising of balloons indicates the speed of the reaction, in the computerized laboratory, the rise in gas pressure is measured using gas

pressure sensors, and in interactive simulation results are presented as graphs and flasks with balloons.

Gas exchange in breathing

The main goal of the exercise is to show that the composition of gasses in inhaled air is different from that in exhaled air. Oxygen is consumed in respiration and carbon dioxide is released. The differences are not constant but are in correlation with the activity. In the classical variant, a volunteer from each group exhales air through a straw into a sealed plastic bag with known volume. The exhaled air is poured into distilled water. Carbon dioxide forms a weak acid with the water, which results in a change of pH. The drop in pH can be registered with a pH meter or as a change in colour of bromthymol blue as an indicator. In the computerized version of the experiment, a volunteer exhales air into a plastic bag, and a gas oxygen sensor is used to record changes. Experiments can be repeated under other conditions (after some kind of activity) with the same or other volunteers. In interactive simulations, changes are presented as a drop in the concentration of oxygen in inhaled air and a rise of carbon dioxide in exhaled air.

Heart rate

The main task of the exercise is to examine differences in heart rate among students, changes caused by some sort of activity and the speed of recovery to an initial state. A stop watch is used to measure arterial pulse in the classical method; a heart rate monitor is used in the computerized laboratory. In simulations, students can choose between three different persons of varying gender (a student, a sportsman and someone overweight) and examine differences in heart rates before and after activity or between persons.

Pre-test and post-test

The quality of knowledge for each method of laboratory work was tested with a pre-test and an equal post-test. Students completed the pre-test before doing the exercises and the post-test after each exercise. The test for each exercise comprised tasks of factual knowledge, connection and use of knowledge, and tasks of high cognitive levels (solving new problems, independent interpretation and evaluation). The reliability test was done with Cronbach´s α. Cronbachs´ α for the Activity of yeast test was 0.84; for the Heart rate test Cronbachs´ α = 0.89, and for Gas exchange in breathing it was α = 0.74.

Microsoft® Excel 2007 was used for input data. Statistical analyses were done with the statistical package SPSS 17.0. One way ANOVA was used to examine differences between knowledge on the pre-test and on the pos-test. With multiple regressions we tested the influence of selected factors on results for knowledge at high cognitive levels.

RESULTS

The students´ leisure-time interests differ according to their gender.

With one way ANOVA, differences by gender for ten leisure activities were tested (Table 1). Not all students filled in the space for gender, and these were not included in the analyses. From Table 1 we can conclude that students´ most popular activities during leisure time, by gender, is hanging out with friends. In nine of the leisure activities there are no statistically significant differences by gender except in the case of reading books; girls are more likely to read books than boys ($F_{1, 188}$ = 7.42, (p = 0.01)).

Table 2: Popularity of leisure activities by gender; (1–most popular, 10–less popular).

No.	Leisure activity	Gender	N	M	SD	SE	F	*p*

1	Hanging out with friends.	male	67	3.48	2.94	0.36	0.67	0.42
		female	122	3.11	2.91	0.26		
		total	189	3.24	2.92	0.21		
2	Watching TV or listening to music.	male	67	4.37	2.82	0.34	2.24	0.14
		female	122	3.77	2.55	0.23		
		total	189	3.98	2.66	0.19		
3	Playing sport.	male	68	3.60	2.91	0.35	3.03	0.08
		female	121	4.32	2.62	0.24		
		total	189	4.06	2.74	0.20		
4	Playing on the computer.	male	66	4.03	2.79	0.34	2.03	0.16
		female	122	4.61	2.63	0.24		
		total	188	4.41	2.69	0.20		
5	Helping parents.	male	67	4.67	2.28	0.28	0.00	1.00
		female	122	4.67	2.43	0.22		
		total	189	4.67	2.37	0.17		
6	Spending time in nature.	male	66	5.86	2.69	0.33	0.86	0.36
		female	121	5.45	2.98	0.27		
		total	187	5.60	2.88	0.21		
7	Reading books.	male	67	6.55	2.91	0.36	7.42	0.01
		female	122	5.38	2.79	0.25		
		total	189	5.79	2.89	0.21		
8	Studying school subjects.	male	66	6.65	2.65	0.33	0.05	0.83
		female	121	6.74	2.89	0.26		
		total	187	6.71	2.80	0.21		
9	Playing musical instrument.	male	65	6.71	3.45	0.43	1.62	0.20
		female	120	7.37	3.31	0.30		
		total	185	7.14	3.36	0.25		
10	Being bored.	male	65	7.12	3.31	0.41	0.47	0.49
		female	120	7.46	3.09	0.28		
		total	185	7.34	3.17	0.23		

Legend: No. = rank of activity popularity; N = number of students; M = mean; SD = standard deviation; SE = standard error.

Students´ most popular leisure-time activity is hanging out with friends. Their other activities are presented in Table 1.

Whether intellectual activities (watching TV, reading books, playing on the computer and studying school subjects) in leisure time influenced the development of high cognitive levels of knowledge can be seen in Tables 2 - 4. In the tests Activity of Yeast and Heart rate, one of six tasks was set at a high cognitive level. In the test Gas exchange in Breathing, two of nine tasks were at high cognitive levels. In Model 1 with multiple regressions we tested whether intellectual activities in leisure time contributed to better results on tasks requiring high levels of cognitive knowledge. In Model 2 we added some variables that may have influenced results for the same tasks. One of the variables is the school grade; however, for privacy reasons, we are denied the chance to test students' performance levels or intelligence, so we used the final school grade as one of the possible scales. In Slovenia final grades at the end of the year are compiled and students are recognized as excellent, very good, good, fair or failing.

Table 2: Results of linear multiple regressions of variable means for high cognitive levels of task in the Activity of yeast test.

Task 3: Why is bread not sweet after baking although sugar is added before baking?					
Model	**Variables**	***b***	***SE b***	***β***	***t***
1	Constant	0.52	0.29		1.82
	Watching TV	0.04	0.03	0.12	1.38
	Playing on the computer	0.02	0.03	0.06	0.63
	Reading books	0.00	0.02	0.01	0.07
	Studying school subjects	0.02	0.02	0.08	0.97
2	Constant	0.23	0.63		0.36
	Watching TV	0.04	0.03	0.14	1.58
	Playing on the computer	0.02	0.03	0.05	0.58
	Reading books	0.00	0.02	0.01	0.17
	Studying school subjects	0.03	0.02	0.11	1.30
	Method of laboratory work	0.02	0.07	0.02	0.28
	Task 3 (pre-test)	0.21	0.08	0.22***	2.80
	Gender	-0.06	0.13	-0.04	-0.48
	Class	0.04	0.05	0.06	0.75
	School grade	-0.08	0.08	-0.08	-0.99
Note: R^2 = 0.02 for Model 1: ΔR^2 = 0.06 for Model 2. * *p* < 0.001, N = 176.**					

In the test Activity of yeast the high cognitive levels question was, ˝Why is bread not sweet after baking although sugar is added before baking?˝ From the results in Table 2, we can see that none of selected intellectual leisure-time activities influenced in the development of high cognitive levels of student knowledge. The sole predictor of better student knowledge in the post-test was students´ pre-knowledge, which we established during the pre-test (β=0.22, p<0.001).

Table 3: Results of linear multiple regression of variable means for high cognitive levels of task in the Heart Rate test

Task 6: When does the heart rate rise at times without physical activity?					
Model	**Variables**	***b***	***SE b***	***β***	***t***
1	Constant	1.10	0.25		4.39
	Watching TV	-0.01	0.02	-0.06	-0.60
	Playing on the computer	0.03	0.02	0.11	1.16
	Reading books	0.02	0.02	0.07	0.78
	Studying school subjects	-0.01	0.02	-0.03	-0.32
2	Constant	1.26	0.52		2.43
	Watching TV	0.00	0.02	-0.01	-0.16
	Playing on the computer	0.01	0.02	0.03	0.33
	Reading books	0.03	0.02	0.12	1.37
	Studying school subjects	0.00	0.02	-0.01	-0.09
	Method of laboratory work	-0.02	0.06	-0.03	-0.40
	Task 6 (pre-test)	0.34	0.08	0.36***	4.47
	Gender	-0.09	0.11	-0.07	-0.80
	Class	-0.01	0.04	-0.02	-0.26
	School grade	-0.09	0.06	-0.11	-1.33
Note: R^2 = 0.01 for Model 1: ΔR^2 = 0.15 for Model 2. *** p < 0.001, N = 163.					

In the Gas exchange in breathing test, the high cognitive level question was, ˝Why during strenuous physical activity sport do we breathe through the nose and not through the mouth?˝ From the results in Table 3 we can see that none of the selected intellectual leisure-time activities are influential in the development of high cognitive levels of knowledge among students. What did contribute to better student knowledge on the post-test was students´ pre-knowledge, which we measured on the pre-test (β=0.36, p<0.001).

Table 4: Results of linear multiple regression of variable means for high cognitive levels for a task in the Gas exchange in breathing test

Task 4: Why during strenuous physical activity or sport do we breathe through the nose and not through the mouth?					
Model	**Variables**	***b***	***SE b***	***β***	***t***
1	Constant	0.49	0.22		2.20
	Watching TV	0.06	0.02	0.25**	2.85
	Playing on the computer	0.01	0.02	0.04	0.39
	Reading books	0.02	0.02	0.08	0.95
	Studying school subjects	0.01	0.02	0.05	0.59
2	Constant	-0.33	0.46		-0.72
	Watching TV	0.06	0.02	0.26**	2.96
	Playing on the computer	0.01	0.02	0.03	0.31
	Reading books	0.02	0.02	0.08	0.95
	Studying school subjects	0.02	0.02	0.10	1.26
	Method of laboratory work	0.00	0.05	0.00	-0.03
	Task 4 (pre-test)	0.31	0.07	0.33***	4.37
	Gender	-0.09	0.10	-0.07	-0.90
	Class	0.04	0.04	0.08	1.10
	School grade	0.05	0.06	0.07	0.96
Note: R^2 = 0.07 for Model 1: ΔR^2 = 0.11 for Model 2. ** p < 0.01, *** p < 0,001, N = 169.					
Task 8: We have been flown by helicopter to the top of Kredarica Mountain. On disembarking from the helicopter, we should be breathing faster. Try to explain why.					
Model	**Variables**	***b***	***SE b***	***β***	***t***
1	Constant	1.05	0.20		5.36
	Watching TV	0.00	0.02	0.00	0.01
	Playing on the computer	-0.01	0.02	-0.08	-0.84
	Reading books	0.00	0.02	-0.02	-0.23
	Studying school subjects	-0.03	0.02	-0.13	-1.53
2	Constant	0.80	0.40		2.01
	Watching TV	0.01	0.02	0.03	0.27
	Playing on the computer	-0.02	0.02	-0.11	-1.14
	Reading books	0.00	0.02	-0.03	-0.29
	Studying school subjects	-0.02	0.02	-0.13	-1.45
	Method of laboratory work	0.06	0.05	0.09	1.13
	Task 8 (pre-test)	0.18	0.07	0.21**	2.64
	Gender	-0.09	0.09	-0.09	-1.04
	Class	0.01	0.03	0.02	0.27
	School grade	0.02	0.05	0.04	0.44
Note: R^2 = 0.02 for Model 1: ΔR^2 = 0.06 for Model 2. ** p < 0.01, N = 169.					

In the Heart rate test the first high cognitive level question was, ˝ Why during strenuous physical activity or sport do we breathe through the nose and not through the mouth?˝ and the second: ˝We have been flown by helicopter to the top of Kredarica Mountain. On disembarking from the helicopter, we should be breathing faster. Try to explain why˝. From the results in Table 4, we can see that answer to the first question were influenced by watching TV (β=0.26, p<0.01), and by students´ pre-knowledge (β=0.33, p<0.001), but on the second question only the students´ pre-knowledge influenced the development of high cognitive levels of knowledge (β=0.21, p<0.01).

DISCUSSION

Few studies have examined the link between home computer usage and school achievement. One study from the USA (Attewell and Battle, 1999) indicates a connection between most school subjects and home-PC usage, even after correcting for socio-economic status. In our studies we did not examine students´ socio-economic status but just the popularity of leisure activities. Students have home access to internet surfing (Kuhlemeier and Hemker, 2007), but the question is: what are the content and goals of this internet surfing? According to our research, playing on the computer is not the dominant activity among students in lower secondary school; instead, hanging out with friends takes first place. This is not surprising because we are social beings and we need interactive relations and socialization.

In a Scandinavian sample of secondary school students, Leino (2003) found a positive relation between PC-usage and grades achieved in academic school subjects. He claimed that this relationship might be explained by the individual's level of literacy. Poor readers/writers did not do as well in most school subjects, and they used computers infrequently because this required reading/writing ability. In another study, Naevdal (2004) found that only school-relevant PC activities like information seeking and doing lessons predicted general school achievement; playing and chatting did not. The use of a home computer to obtain information and to handle text documents was obviously an advantage when it came to marks in English, independent of the total PC-time or of gender. These activities may be interpreted as regular school work, and work on school subjects at home usually improves school achievement (Nævdal, 2007). In general, if a student´s search topic on the computer were Science-related, they would have better results in knowledge. The question is not how knowledge is gained but the quality of the students´ knowledge. In Wills and McNaught´s (1996) research, we find a conclusion about the quality of knowledge acquired through classical and computer-supported learning. Students with traditional methods of education achieved better basic cognitive levels of knowledge (knowledge and understanding); meanwhile, students using computer-supported learning achieved better high cognitive levels of knowledge (analysis, synthesis and evaluation). We did not get similar results; the methods for different laboratory work (classic, computer-supported or computer simulation) do not contribute to higher cognitive levels of knowledge (Table 2-4). We also confirmed that using computers during students´ leisure time does not contribute to achievement of high cognitive levels of knowledge (Table 2-4). The same goes for other intellectual activities such as reading books or studying school subjects. In one case (the Heart rate test), watching TV did contribute to higher cognitive levels of knowledge (Table 4). We think that students may have been watching sporting events where they could have gained knowledge about breathing during activities. Gender, class and students´ school grades do not contribute to high cognitive levels of knowledge.

CONCLUSIONS

For the development of high cognitive levels of knowledge, what matters is the subject of all the leisure-time activities and previously-acquired knowledge but not the exercise methodology used in laboratory. Our results provide partial confirmation of Johnston (1997), Winberg and Berg, (2007), who emphasized the significance of pre-knowledge for effective laboratory based learning: ˝First-time, unprepared learners are not in a position to process laboratory experiences with understanding'' (p. 267), he wrote, claiming that what and how you learn is controlled by what you already know. The most important single factor influencing learning is what the learner knows. Ascertain this and teach accordingly (Ausubel, 1968).

ICT was included in education to facilitate the teaching, studying and training of students for quality use of ICT in later life (employment and social life). Gürbüz et al (2009) claimed that ICT influences students and teachers positively. In previous research (Špernjak and Šorgo, 2009b) we established that ICT in biology laboratory work is, for students aged 11 – 15, interesting, motivating and effectively just like classical methods of laboratory work. For the students´ benefit, it is a teacher´s duty to make a varied selection of pedagogical methods and good connections between subjects where students can make sense of pre- knowledge and later even attain high cognitive levels of knowledge.

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DEVELOPMENT AND EVALUATION OF *MANGA* EDUCATIONAL MATERIALS FOR SCIENCE TEACHERS

Daikoku Takafumi

Center for Teacher-Training Course, Doshisha Women's College

tdaikoku@dwc.doshisha.ac.jp

Takenaka Makiko

Center for Research in Education and Human Development, Oita University

tmakiko@cc.oita-u.ac.jp

Nakamura Hisayoshi

Narika Corporation

nakamura@rika.com

Inagaki Shigenori

Graduate School of Human Development and Environment, Kobe University

inagakis@kobe-u.ac.jp

ABSTRACT

This research aims to develop educational materials for teachers using *manga* as a support aid and to verify the materials' effectiveness. A practical evaluation was attempted targeting 83 second-year students at a women's college who were not specializing in science and who wished to become elementary school teachers, and 27 high school lab teachers specializing in science. The results show that both groups evaluated the *manga* as easy to read and as an effective method for understanding the characteristics of laboratory materials and for learning methods of instruction.

Keywords: *teacher education, narrative approach, manga, science materials, laboratory skills*

INTRODUCTION

The primary goal of teacher education is to cultivate teachers' qualities and capabilities and heighten their expertise in prospective teachers. The principles of Pedagogical Content Knowledge (PCK) are widely viewed as a model for these qualities and capabilities (e.g., Gess-Newsome & Lederman, 1999; Mishra & Koeher, 2006). PCK is knowledge directly linked to the teachers' practical abilities and expertise. In particular, in the field of science education, the understanding of laboratory equipment and materials and knowing how to use teaching tools effectively are essential practical abilities. However, in most cases in Japanese elementary schools, teachers who do not specialize in science are teaching science classes. Therefore, it cannot be said that their knowledge and understanding of laboratory equipment is sufficient. In fact, many elementary school teachers say that science is their weakness (Hanaue et al., 2009). This is why we have created teacher educational materials using *manga* as a tool to provide elementary school teachers with necessary science knowledge. *Manga* is a medium that enables the reader to understand content in a relatively short time. Important messages can be embedded into symbols, such as pictures or lines spoken by characters, making *manga* an ideal tool for learning materials that use the narrative approach as advocated by Yoshikawa (2007). Daikoku et al. (2009) developed *manga* educational material for teacher education in order to establish a cooperative learning method using this narrative approach, and they have confirmed its effectiveness. Therefore, this study developed *manga* educational material for teachers who are teaching science classes using the narrative approach, and then evaluated the material. The material was evaluated by students at a women's college who wish to become elementary school teachers but who have a weakness in science instruction, and high school science laboratory teachers who specialize in science. The evaluation of the *manga* educational material by both parties helps to more fully assess the effectiveness of the material for science teachers.

OVERVIEW OF *MANGA* EDUCATIONAL MATERIAL

The *manga* educational material examined here deals with instructions on using a hand crank generator (Figure 1) to learn about units of energy. The character of the teacher in the *manga* educational material is a woman. Since the majority of elementary school teachers

Figure 1: Hand crank generator

are women, it was believed that a female character would be easier to relate to.

Matsumoto et al. (2009) report that more than 70% of elementary schools do not have hand crank generators due to insufficient experiment equipment for physics education; therefore, it is assumed that teachers have little experience in using them in classes. Furthermore, college students aiming to become elementary school teachers have had very little science education in their elementary, middle, and high school years due to massive cutbacks in science education that stem from a relaxed education policy (yutori kyoiku); thus, they have little or no experience in using hand crank generators. The survey targeting 83 second-year students at a women's college who wish to become elementary school teachers revealed that 86% of them had no experience with hand crank generator experiments.

Implementation of hand crank generators in schools began in 1981. Currently, several different types of hand crank generators are used in science labs. The differences in the functions and usage of each type of hand crank generator are narrated using *manga*, along with actual classroom situations. Reading this *manga* educational material will enable teachers to not only learn in a simple way how to operate the generators or how to instruct students, but also to cultivate the ability to handle unexpected problems during class and to understand the structural characteristics of the experiment equipment and make appropriate judgments in various situations.

Instead of showing the phenomenon in which cranking the hand crank generator generates electricity and illuminates a miniature light bulb, Figure 2 shows a recognition of how the light differs among groups and how the miniature light bulb goes out due to excess voltage. There can be two causes for this. One is that the capacity of the hand crank generator exceeds the withstanding voltage of the light bulb. The other is that the teacher lacks a sufficient grasp of its capacity and cannot provide appropriate experiment instructions.

Then, there is the manner in which the teacher handles the situation when the light bulb goes out. The phrase “Oh! You too?” indicates that this is not the only group with a light bulb that is out, and the phrase “What should I do?” and the facial expression shows insufficient preparation for such a situation. This is because the teacher did not anticipate the light bulbs going out; in other words, the teacher was using a hand crank generator without having sufficient understanding of the relationship between the generator’s function and the experiment itself, and she did not have enough spare light bulbs to prepare for unexpected problems. In order to prevent such problems, in the *manga* educational material, product information for the hand crank generator is shown as modified to an appropriate voltage (approx. 3 volts) so that the miniature light bulb will not go out even if the generator is cranked rapidly. However, another point that must be derived from this series of scenes is that such trouble can be avoided if the teacher provides appropriate preliminary instructions and also pays sufficient attention to students during the experiment.

Figure 2: A scene from the *manga* educational material

Apart from the issue of the teacher’s instructional abilities, students often have a tendency to ignore study guidance and set procedures when they find the resulting phenomenon interesting or when they are intrigued by the differences between their experiment and that of someone else. Therefore, the development and improvement of experiment material with consideration of the characteristics of the students conducting the experiment as well as ease of operation is indispensable. However, this is not meant to compensate for the teacher’s lack of sufficient instructional ability. Rather, in the current school situation in which new and old experiment materials coexist, teachers who are able to provide appropriate instructions to students are called for more than ever.

Moreover, this *manga* educational material is designed so that science teachers with more experience and skills can gain deeper understanding. Take the example in Figure 3, where a teacher is lost in thought in the science lab. Shown behind the teacher is a shelf

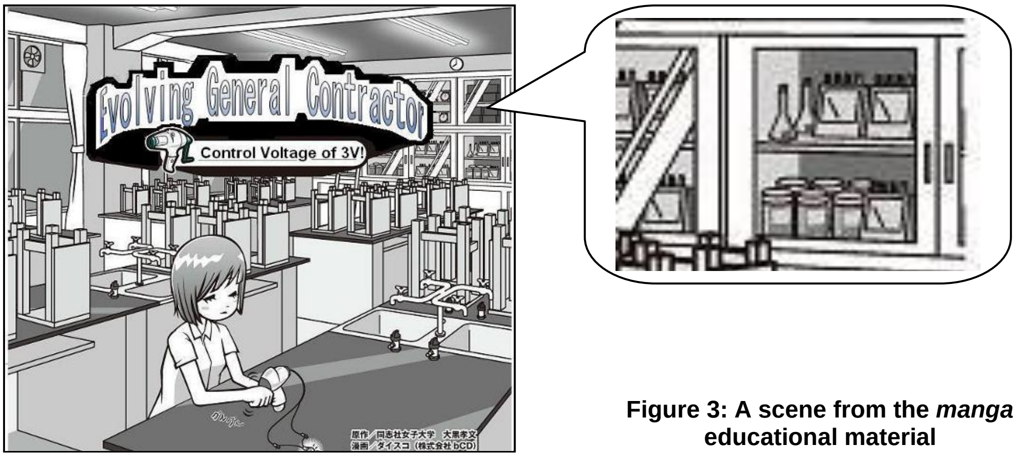

Figure 3: A scene from the *manga* educational material

containing experiment materials. To untrained eyes, this might seem like a well-organized shelf, but to teachers who teach in science labs, it is obvious that chemical experiment materials and electricity experiment materials should never be stored on the same shelf. Furthermore, people might tend to focus on the students conducting experiments in Figure 4, but experienced teachers will immediately realize that experiments dealing with weak light such as the miniature light bulb would never be conducted in a classroom where the curtains are not shut and the sunlight is streaming in.

In other words, issues with instructional skills and experiment skills are embedded as viewpoints in order to direct the readers’ focus to the ideas being conveyed; the amount of experience, knowledge, and skills that teachers have will affect what each teacher can gain from the *manga*. This indicates that *manga* educational materials can be highly effective in cultivating context adaptability and situation assessment ability.

Figure 4: A scene from the *manga* educational material

EVALUATION OF THE *MANGA* EDUCATIONAL MATERIAL

The evaluation in this study consisted of a questionnaire survey administered to 83 college students attending a private women's college in Kyoto Prefecture who want to become elementary school teachers but who do not specialize in science (conducted October 19, 2009) and 27 high school science laboratory teachers in Oita Prefecture (conducted November 13, 2009). The aim was to assess the effectiveness of *manga* educational material by having it evaluated by both college students who are weak in science instruction and laboratory teachers specializing in science.

EVALUATION 1: EVALUATION BY QUESTIONNAIRE SURVEY

Table 1 lists the survey questions. The survey content consisted of seven questions (1 to 7) on the "Ease of Reading *Manga*" and 17 questions on "Effectiveness of the *Manga* Educational Material." Within "Effectiveness of the *Manga* Educational Material," questions were asked about (1) understanding of functions and usage of experiment materials by the *manga* educational material (8 to 14), (2) comparison of explanations by the *manga* educational material and by conventional texts (15 to 18), (3) effectiveness of the *manga* educational material in depicting the functions and usage of experiment materials (19 to 22), and (4) effectiveness and expectations of the *manga* educational material for teachers with a weakness in science instruction (23, 24).

The results were analyzed based on a four-level rating method. For each question, answers were categorized into "Positive" and "Negative"; the tendencies of respondents were assessed using the exact probability test (both sides).

EVALUATION 2: EVALUATION BY FREE WRITING

Table 1: Questions regarding *manga* educational material

[Ease of Reading *Manga*]

1 Students can relate to the character design in the *manga* educational material.
2 The *manga* educational material is easy to continue reading.
3 The way in which frames progress in the *manga* educational material is easy to understand.
4 The text of the *manga* educational material is easy to read.
5 The amount of text in the *manga* educational material is appropriate.
6 The *manga* educational material accurately depicts the experiment materials, lab equipment, etc.
7 The *manga* educational material accurately depicts actual classroom situations.

[Effectiveness of the *Manga* Educational Material]

(1) Understanding of functions and usage of experiment materials by the *manga* educational material

8 The *manga* educational material aids in understanding the functions of educational material.
9 The *manga* educational material shows the usage of experiment materials in an easy-to-understand manner.
10 The *manga* educational material shows the problems with using experiment materials in an easy-to-understand manner.
11 The *manga* educational material shows the development concept of experiment materials in an easy-to-understand manner.
12 Even when teaching students how to use the experiment materials after reading *manga* educational material, there are times when desirable experiment results are not achieved, depending on the characteristics of the experiment materials.
13 After reading the *manga* educational material, I understand why the experiment material needed to be improved.
14 Because I understood why the experiment materials needed improvement after reading the *manga* educational material, I know what I need to watch out for when providing experiment instruction, even when I'm using outdated experiment materials.

(2) Comparison of explanations by the *manga* educational material and by conventional texts

15 The *manga* educational material helps me understand the function of the experiment materials better than plaintext.
16 The *manga* educational material explains how to use the experiment materials better than plain text.
17 The *manga* educational material shows the problems with using experiment materials better than plain text.
18 The *manga* educational material explains the development concept of experiment materials better than plain text.

(3) Effectiveness of the *manga* educational material in depicting functions and usage of experiment materials

19 I think it is effective to use the *manga* educational material to explain the functions of the experiment materials.
20 I think it is effective to use the *manga* educational material to better explain how to use the experiment materials.
21 I think it is effective to use the *manga* educational material to better show the problems with using the experiment materials.
22 I think it is effective to use the *manga* educational material to better explain the development concept of the experiment materials.

(4) Effectiveness and expectations of the *manga* educational material for teachers with a weakness in science instruction

23 I think it is effective to use the *manga* educational material for teachers with a weakness in science experiments.
24 If other *manga* educational material introducing_other experiment materials exists, I would like to read it.

Second-year college students were asked to answer freely on the “Effectiveness of the *Manga* Educational Material.” Their answers were reviewed based on the four perspectives related to “Effectiveness of the *Manga* Educational Material.”

RESULTS AND CONSIDERATION

EVALUATION 1: RESULTS AND SPECULATION OF QUESTIONNAIRE EVALUATION

Table 2 shows the results of the questionnaire. In both groups of college students and laboratory teachers, the numbers of positive answers for almost all questions were significantly larger ($p<0.01$). To compare the two groups, each question was assessed using the chi-square test. No differences existed for any questions regarding ease of reading or effectiveness. This suggests that both groups felt the same way about ease of reading and effectiveness.

Regarding “Ease of Reading *Manga*,” the above results show that the *manga* with its characters and lines is easy to relate to and read. This can be understood as the result of the careful design of the *manga* educational material to target female teachers, who comprise the majority of elementary school teachers.

As for “Understanding of functions and usage of experiment materials by the *manga* educational material,” a positive evaluation was given on all questions. In particular, the reason why the experiment material was improved was understood by almost everyone. This can be considered the achievement of one of the goals of this educational material, which is to explain the reason behind the development of experiment material.

Table 2: Questionnaire results

No.	College students			High school science laboratory teachers		
	Positive	Negative	SS	Positive	Negative	SS
1	82	1	**	22	5	**
2	73	10	**	26	1	**
3	71	12	**	27	0	**
4	73	10	**	27	0	**
5	83	0	**	23	4	**
6	53	30	*	20	7	*
7	71	12	**	24	3	**
8	71	12	**	21	6	**
9	60	23	**	20	7	*
10	62	21	**	23	4	**
11	65	18	**	21	6	**
12	68	15	**	26	1	**
13	80	3	**	26	1	**
14	67	16	**	26	1	**
15	80	3	**	25	2	**
16	76	7	**	25	2	**
17	78	5	**	24	3	**
18	74	9	**	24	3	**
19	79	4	**	27	0	**
20	81	2	**	27	0	**
21	83	0	**	27	0	**
22	78	5	**	26	1	**
23	81	2	**	24	3	**
24	80	3	**	23	4	**

**$p<.01$ *$p<.05$

Regarding "Comparison of explanations by the *manga* educational material and by conventional texts," all answers proved the effectiveness of the *manga* educational material. This is due to the characteristics of the *manga* material itself: it is easy to understand and a comparison of the context can be easily done by looking backward or forward to other frames.

A high evaluation was received for all questions regarding “Effectiveness of the *manga* educational material in depicting functions and usage of experiment materials” as well, especially for the question of whether or not issues regarding usage of experiment materials are easy to understand, to which everyone answered positively. It is likely that this is due to the successful implementation of the narrative approach, which allows readers to recognize problems by building them into the story of the *manga*.

Lastly, regarding “Effectiveness and expectations of the *manga* educational material for teachers with a weakness in science instruction,” almost everyone acknowledged its effectiveness and said that they would like to read more new *manga*. This can be interpreted as readers empathizing with the teacher in the *manga*, who is not good at science instruction.

There was no difference in the evaluation by the two subject groups. This indicates that the validity of the *manga* educational material was confirmed, since experiment teachers specializing in science gave high evaluations, and also that this *manga* educational material is an effective teaching method for teachers who have a weakness in science instruction.

EVALUATION 2: RESULTS AND SPECULATION OF FREE WRITING EVALUATION

Table 3 shows representative examples of free writing answers by college students with a weakness in science instruction, based on the four perspectives of “Effectiveness of the *Manga* Educational Material.”

(1) Understanding of functions and usage of experiment materials by the *manga* educational material

Many of the free writing answers mentioned experimental material, usage, and method of instruction; this indicates that students were able to read through the material with an awareness of the relationship between the material and classroom instruction.

(2) Comparison of explanations by the *manga* educational material and by conventional texts

In free writing answers, the difference in the method of conveying information between text and *manga* was mentioned. This indicates that students were able to compare and contrast the context by looking backward or forward to other frames, enabling them to easily recognize the causal connection of problems that occur.

(3) Effectiveness of the *manga* educational material in depicting the functions and usage of experiment materials

From the expression “hidden traps were very difficult to find” found in the free writing answers, it can be seen that the narrative approach that allows readers to recognize problems by reading into the story of the *manga* is working effectively. In addition, the evaluation stating that “it can be read over and over again” also shows a characteristic of the *manga* educational material.

(4) Effectiveness and expectations of the *manga* educational material for teachers with a weakness in science instruction

As can be seen from the free writing answers, for students with a weakness in science instruction, *manga* educational material can be an effective method for conveying information. Also, the reading of *manga* can be interpreted as a willingness to improve as a science teacher.

This shows that the *manga* educational material was evaluated as effective by college students with a weakness in science instruction. It suggests that *manga* educational materials can be an effective tool to help teachers who are weak in science understand the characteristics of experiment materials and learn methods of experiment instruction.

CONCLUSION

Table 3: Examples of free writing answers by second-year college students

(1) Understanding of functions and usage of experiment materials by the *manga* educational material
− In a real classroom setting, it was easy to get into. Characteristics of hand crank generators were easy to understand with *manga*. − What to watch out for when conducting experiments, and what exactly was improved were very easy to understand. How to use it was a little difficult to understand.
(2) Comparison of explanations by the *manga* educational material and by conventional texts
− What I couldn't understand before with just instructional text became easier to understand with *manga*. When the miniature light bulb went out after students cranked the generator too hard, at first I thought the generator broke, but after I kept reading, I understood that the voltage became too high. − I didn't feel much like reading the first pamphlet (manual) I saw, so the difference between the new and the old hand crank generator was difficult to understand, but the *manga* made it easy.
(3) Effectiveness of the *manga* educational material in depicting functions and usage of experiment materials
− The *manga* educational material was easier to relate to than text, and was more interesting. Also, I thought the *manga* educational material was intriguing because one could read it over and over again. I'd like to read more such *manga* educational material in the future. − Unlike text, *manga* allowed easy understanding of the contents, and made learning fun. But, although fun, this enjoyable *manga* had many hidden traps, which were very difficult to find.
(4) Effectiveness and expectations of the *manga* educational material for teachers with a weakness in science instruction
− Text is often not enough to explain certain things; therefore, I think this *manga* educational material is very useful. I think it can be very effective in practical situations, and I myself would love to read more. − Very easy to understand. I am not good at science and have anxieties about whether I can teach students adequately, so I would like to read such *manga* when I become a teacher. I would like to have easy-to-understand explanations of the traps hidden in the *manga* attached at the end, too.

This study developed teacher educational material using *manga* to support science teachers, and evaluated its effectiveness. *Manga* is a medium that allows readers to follow a story in a relatively short time, and it allows the creators to embed important messages in the drawings and spoken lines. In the *manga* educational material dealing with how to provide usage instructions for hand crank generators, the problems in instruction skills and experiment skills were narrated in order to focus on the important messages.

The effectiveness of the *manga* educational material was evaluated by both college students with a weakness in science instruction and experiment teachers specializing in science. Both groups provided high evaluations, indicating that the *manga* educational material is an effective educational tool for science teachers. The results of this research demonstrate the possibility of using *manga* for teacher education.

In the future, we would like to continue this development in order to realize a more effective utilization of *manga* educational material, such as creating teachers' manuals and case study programs.

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HUMAN RESOURCES DEVELOPMENT FOR THE SUSTAINABILITY ISSUES: JAPAN'S CHALLENGES

Makoto TAMURA

Institute for Global Change Adaptation Science, Ibaraki University

tamura@mx.ibaraki.ac.jp

Takahide UEGAKI

Graduate Program on Sustainability Science, Ibaraki University

t-uegaki@mx.ibaraki.ac.jp

ABSTRACT

In order to build a sustainable society, there is a need for the development of human resources who can deal with unsolved sustainability issues and related environmental issues. First, this paper examines differences between the human resources developed through conventional education and through sustainability education. Second, this paper discusses the core competencies required for the sustainability education and introduces our educational challenges in Japan.

Keywords: *sustainability education*, *skills*, *mind*, *knowledge*

INTRODUCTION

In order to build a sustainable society, there is a need for the development of human resources who can deal with unsolved sustainability issues and related environmental issues. When defining the human resources desired, we must clarify what core competencies are required of these resources. Asking what capabilities should be acquired is a question essential to human resource development, one that enables us to share a specific vision of the human resources desired, and also provides clues for the implementation of this vision in practical education. Therefore, alongside education for sustainable development (ESD), which has grown in popularity internationally in recent years (see, e.g., UNESCO, 2005, 2007), there is a need for education that can provide a comprehensive understanding of the global, social, and human systems and their interrelationships, which are regarded as the essential components of sustainability science (Komiyama & Takeuchi, 2006). For example, in the context of climate change issue caused by the mutual contradiction between global and social systems, the role of human resource development is significant. Education or capacity development may reduce the adverse effects of climate change.

In Japan, the five participating universities (University of Tokyo, Kyoto University, Osaka University, Hokkaido University, and Ibaraki University) in the Integrated Research for Sustainability Science (IR3S) are collaborating on the educational program that can nurture specialists who can make an active contribution to the construction of a sustainable society on the global stage (Figure 1). For instance, the Graduate Program on Sustainability Science (GPSS) in Ibaraki University, which has started on April 2009, is an interdisciplinary program intended to produce specialists in sustainability science who will contribute, domestically and internationally.

This paper discusses the core competencies required of the sustainability education and introduces some challenges for the human resource development. This paper mainly focuses on the activities for sustainability education in Japan. For the discussion and activities about the other countries, see, e.g., Segalàs et al (2009).

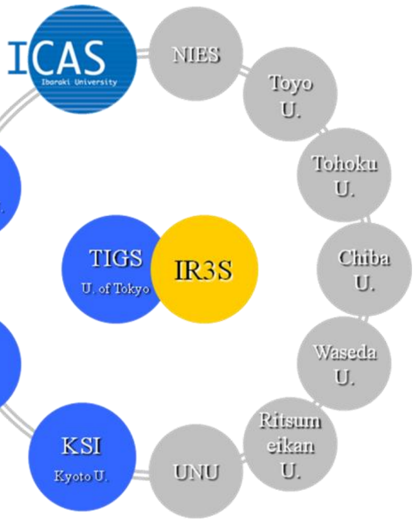


Figure 1 I Integrated Research for Sustainability Science (IR3S)

GOALS FOR HUMAN RESOURCE DEVELOPMENT

Table 1 summarizes the differences between human resources required in conventional education and sustainability education in the case of Japan. Conventional education in Japan has largely focused on the accumulation of knowledge. This tendency is particularly prominent in higher education (see, e.g., Central Council for Education, 2003). Undergraduates and graduates dedicate themselves to the acquisition of segmented expertise by taking specialized and segmentalized courses from the time they enter universities and graduate schools. Conventional undergraduate and graduate education has adopted this approach because the main goal of this education is to impart expertise. The root of this tendency is, no doubt, a presumption that higher education best serves society by producing human resources who are specialists who can apply the latest specialized knowledge in specific fields.

However, the fundamental issue addressed by sustainability science is how to reconstruct the global, social, and human systems into appropriate forms in order to establish a sustainable society, based on a recognition that there are mutual contradictions among these three systems. Therefore, the human resources trained by sustainability education must have in their minds a long-term vision for building a sustainable society and must acquire competencies that can contribute to solving the problems that are actually occurring in various areas of society.

The following characteristics of human resources fostered by sustainability education can be identified: (1) their activities are problem-oriented rather than discipline-oriented; (2) their field of action is envisioned as a broad field embracing various occupations as well as various activities appropriate to diverse social perspectives but sharing the goal of building a sustainable society; and (3) students belonging to any discipline may be candidates for sustainability education.

Figure 2 summarizes the desired competencies for the above human resources (Tamura & Uegaki, 2010). In addition to expertise, sustainability education requires comprehensive competencies that combine holistic knowledge, skills, and mind.

Holistic knowledge mainly helps provide human resources with the competency to detach and position themselves. In other words, this competency enables the students to (1) place their own accumulated experiences and knowledge in a larger context, thereby defining their positions, and (2) identify the issues to be dealt with.

Required skills are divided by three components: (1) Communication skills. This includes the ability to understand the emotions of others, see perspectives other than one's own, and build relationships with others. Whether taking a local or global perspective, it is necessary to cooperate with different people with different viewpoints in order to actually resolve problems. (2) Collaboration skills. These are skills in building relationships using communication skills and linking these relationships with various other related factors. With the complex and all-encompassing challenges involved in attaining a sustainable society, the ability to link individual problems to other problems and recognize patterns is critical. Collaboration skills also include the ability to recognize the relationships between different activities occurring at the same time and to bring together the various stakeholders involved. (3) Problem-solving skills. Unlike the ability to link factors or build relationships, which are germane to dealing with individually occurring problems, problem-solving skills include the ability to single out problems and find clues for their resolution. Because efforts to achieve sustainability include a variety of actors, conflict can arise even when care is taken to avoid it. While communication skills can help to prevent conflict before it occurs, problem-solving skills enable us to manage unavoidable conflicts in the best manner possible.

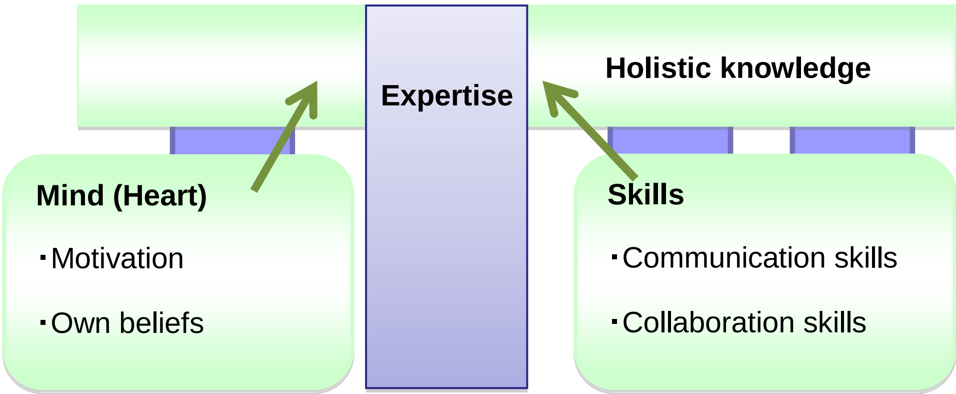
Mind as envisioned here includes the following elements: (1) Motivation. This refers to the mental strength and endurance to bring to completion actions that are initiated. (2) One's own beliefs. A new activity often runs into failure or barriers of some sort. Maintaining one's motivation without giving up requires a strong belief in or rationale for one's own practice. (3) Synchronic consciousness. This is the competency of not being restricted to narrow personal relationships, but rather being able to imagine people around the world in situations different from one's own and striving to communicate with them. This also refers to the ability to expand one's sphere of activity even when in unfamiliar areas or foreign countries. (4) Diachronic consciousness. Behind the ability to motivate people, raise awareness of a problem into a belief, and refine the sensibilities of others sharing the same epoch, is an omnipresent love expressed toward the existence of other individuals and other generations.

Finally, these should be combined with the expertise that is emphasized in conventional education. The human resources we seek to develop should acquire their own core expertise and additionally acquire the specific competencies required for sustainability science. In other words, by learning holistic knowledge and expertise in addition to mind (including motivation, one's own beliefs, and synchronic/diachronic consciousness) and skills (including communication skills, collaboration skills, and problem-solving skills), these human resources will be prepared to discover, identify, and take steps to resolve sustainability issues on their own.

Table 1 Differences between human resources required in conventional education and sustainability education

	Conventional education	Sustainability education
Orientation for action	Discipline-oriented	Problem-oriented
Field	Field in which students can make use of their expertise; specific job descriptions	Local to global fields; various job descriptions
Target	Students who belong to specific faculties, or candidates seeking expertise in specific academic fields	Students who belong to all fields and candidates seeking expertise in various areas of knowledge who also aspire to help build a sustainable society

Figure 2 Core competencies for human resources fostered by sustainability education



CHALLENGES IN JAPAN

Ibaraki University launched its Graduate Program on Sustainability Science (GPSS) in April 2009 (For the other Japanese programs for sustainability education, see, e.g., Onuki & Mino, 2009; Uwasu et al., 2009). Figure 3 shows an outline of this education program. An interdisciplinary program, it is designed for postgraduates and is composed of the Sustainability Science Course and the Sustainability Science Program. The Sustainability Science Course is one of the regular master's courses of the Urban System Planning Course of the Graduate School of Science and Engineering. The Sustainability Science Program is composed of minor courses offered by all graduate schools of Ibaraki University (Humanities, Education, Science and Engineering, and Agriculture). In the case of the Sustainability Science Course, subjects are included in the regular curriculum (a total of 30 credits must include 6 credits from Basic Subjects and 2 credits from Practical Subjects), and students earning the required units of credit will receive a Certificate of the Sustainability Science Course in addition to their master's degree. In the case of the Sustainability Science Program, students can receive a Certificate of the Sustainability Science Program once they have fulfilled the requirement of 6 credits from Basic Subjects or Practical Subjects and 4 credits from Specialized Subjects authorized by the respective graduate schools (this requirement differs slightly depending on the graduate school).

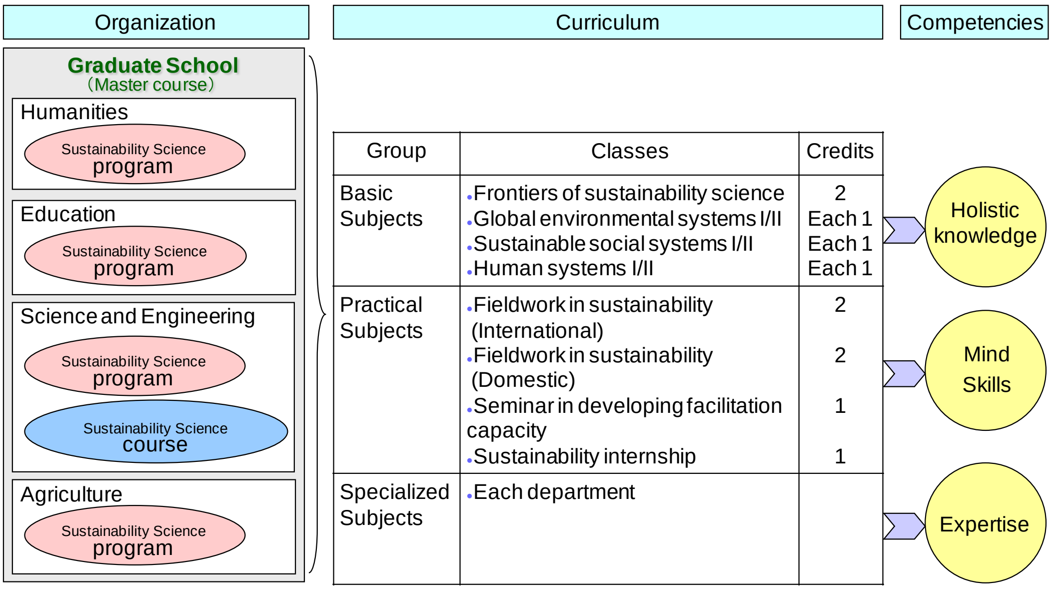
These courses aim to develop not only advanced expertise but also the following three different competencies. The first competency is holistic knowledge of the broad range of issues associated with sustainability science, so as to enable students to adopt different viewpoints as well as position their own expertise in various fields. The second is the development of communication skills to enable students to understand others and form relationships, collaborating skills to encourage various stakeholders to address issues, and problem-solving skills to identify real issues and resolve conflicts. The third is “mind” or “heart,” which includes the motivation to dedicate oneself to the public, having one’s own beliefs to maintain that motivation, and synchronic/diachronic consciousness.

The education model can be referred to as “Education across Mind-Skill-Knowledge” (Shin-Gi-Chi in Japanese). This is an analogy derived from a proverb about traditional Japanese sports that defines Shin-Gi-Tai as the three elements essential to being a great athlete. Shin-Gi-Tai expresses the need in competitive sports for a comprehensive foundation combining physical ability (Tai = body), sophisticated athletic skills (Gi = skill) and sound mind (Shin = mind). The replacement of Tai with Chi (knowledge) yields the expression Shin-Gi-Chi: “Mind-Skill-Knowledge.”

In order to achieve this objective, the curriculum is composed of three main categories. First, Basic Subjects for holistic knowledge aim to help students understand the structures of the global system, social system, and human system, and consider the interactions among these systems from an integrated viewpoint. Second, Practical Subjects aim to nurture the skills and mind needed to work in international or domestic fields where students will experience complex problems, and must communicate and work with people living with those problems. Lastly, Specialized Subjects are offered with the expectation that recipients of sustainability education need expertise in a real field of specialization to which they can commit themselves.

Ibaraki University anticipates that graduates who finish this education program will be equipped to contribute both locally and globally in such fields as government, business, education, international organizations, NGOs and NPOs.

In 2009, as a result, the number of graduate students who registered for and took this educational program numbered 45 for the Sustainability Science Program and 4 for the Sustainability Science Course, for a total of 49 students. This greatly exceeded our original expectations.



Group	Classes	Credits
Basic Subjects	･Frontiers of sustainability science ･Global environmental systems I/II ･Sustainable social systems I/II ･Human systems I/II	2 Each 1 Each 1 Each 1
Practical Subjects	･Fieldwork in sustainability (International) ･Fieldwork in sustainability (Domestic) ･Seminar in developing facilitation capacity ･Sustainability internship	2 2 1 1
Specialized Subjects	･Each department	

Figure 3 Graduate Program on Sustainability Science at Ibaraki University

IMPLEMENTATION OF PRACTICAL SUBJECTS AND EVALUTATION

The Practical Subjects are one of the essential components of the education program. In 2009, the program initiated an international fieldwork seminar (Fieldwork in Sustainability) at Mai Khao village in Phuket, Thailand. Additionally, a domestic fieldwork seminar deals with issues in Oarai City, in Ibaraki Prefecture. Through the group works and discussion between students and people in the site, these fieldworks particularly contributed the education for mind and skills.

'Fieldwork in Sustainability (International)' was implemented in the field at Mai Khao, in Phuket, Thailand from August 22 to 30. Four teaching staffs and 12 graduate students went there from Ibaraki University. They were joined by some teachers and 13 students from Phuket Rajabhat University. In the field, the graduate students from both schools were divided into four groups: a Rice Paddy-Agriculture Team, a Waste-Garbage Team, a Turtle-Biological Conservation Team and an Afforestation Team. Each team drafted a research plan, carried out field investigation and brought their results together and put on a poster. The finished poster introduced the people of Mai Khao village and shared opinions. By working together to complete the poster as well as communicating with the villagers, students in different countries and different graduate schools, though they were from many backgrounds and nationalities, the students were able to work proactively to understand the problems, discover the issues and seek solutions. From this experience, not only was there an increase in the desire to study and learn English, there was also a feeling of accomplishment, a sense of fulfillment and a definite change in level of motivation. On the other hand, the solutions shown in the fieldwork were inadequate, but we hope that with the further accumulation of results, we will see developments from next year on.

For 'Fieldwork in Sustainability (Domestic)', we held a preliminary briefing, listening to a lecturer on September 11. Then from September 12 to 13, we did fieldwork in Oarai, Ibaraki. 20 graduate students took part. Over the two days, they did field surveys and had discussions on four main themes: Coastal Ecology and Clams, Coastal Development and Recreational Beaches, The Water Environment of the Naka River and Lake Hinuma, and Fresh-water Clam Digging and Lake Hinuma. Furthermore, a follow-up discussion was held on September 25. Local knowledge was exchanged and research results were shared. An overall theme of 'How to construct the city using water environment' was put forth, and the results were put on posters by groups.

Just as with 'Fieldwork in Sustainability (International)', students from a variety of backgrounds could proactively understand problems and have the motivation to discover issues and seek solutions through the cooperative work. In the process, they cultivated a desire for learning and an attachment to the field. The preliminary briefing also contributed to the liveliness of the local hearing. Having a workshop to bring the research results of all the various themes together was a good way to develop the ability to form a holistic viewpoint of the field.

Questionnaire surveys of the students were implemented before and after the fieldwork. The questionnaire is divided by qualitative and quantitative one. The former is description of their feelings and comments. One of the significant differences between before and after the fieldwork was the volume of students' description. Most of the students wrote more than before because they learnt many things from the fieldwork. The latter is self-evaluation of their abilities and competencies. They evaluated their scores of abilities from 1 to 5.

Table 2 shows the result of self-evaluation. Most of the components increased after the participation in both International and Domestic fieldwork. On the other hand, some abilities such as interdependence decreased after the fieldwork. During the group work and discussion, students might recognize both possibility and limit of their own abilities. Of course, it should be prudent to examine the results of self-evaluation. However, it is obvious that these Practical Subjects contributed for the students to acquire skills and mind, which are the important competencies for the sustainability education.

Table 2. Self Evaluations for the Students

Fieldwork in Sustainability (International) (*n*=12)

		Before fieldwork (average)	After fieldwork (average)	Difference
Independence	Self responsibility	4.5	4.3	-0.2
	Positiveness	4.6	4.6	0.0
Motivation	Receptivity	4.0	4.0	0.0
	Self-reform	3.8	4.4	0.7
Action	Continuation for the belief	4.0	4.0	0.0
	Responsibility for the results	4.2	4.3	0.1
Sociality	Contribution to the groups	3.9	4.2	0.3
	Contribution to the society	3.8	3.8	0.1
Communication skill	Ability to guess	3.8	3.9	0.1
	Team work	3.8	3.8	-0.1
Thinking faculty	Structural understanding	3.9	4.1	0.2
	Logical understanding	3.4	3.8	0.4
Planning ability	Collection of the information	3.8	4.2	0.3
	Imagination	3.6	3.8	0.2
Managing ability	Ability to analyze	3.7	4.2	0.5
	Ability to correspond	3.8	4.0	0.3

Field Work in Sustainability (Domestic) (*n*=20)

		Before fieldwork (average)	After fieldwork (average)	Difference
Independence	Self responsibility	4.2	4.1	-0.1
	Positiveness	4.4	4.2	-0.2
Motivation	Receptivity	4.3	4.4	0.1
	Self-reform	3.9	4.1	0.2
Action	Continuation for the belief	3.7	3.7	0.0
	Responsibility for the results	3.8	3.7	-0.0
Sociality	Contribution to the groups	3.8	4.1	0.3
	Contribution to the society	3.5	3.5	0.1
Communication skill	Ability to guess	3.7	4.2	0.5
	Team work	3.7	4.4	0.7
Thinking faculty	Structural understanding	3.3	4.3	1.0
	Logical understanding	3.5	3.7	0.3
Planning ability	Collection of the information	3.7	3.9	0.2
	Imagination	3.4	3.7	0.3
Managing ability	Ability to analyze	3.8	4.1	0.3
	Ability to correspond	3.4	3.9	0.6

CONCLUSION

This paper firstly examines differences between the human resources developed through conventional education and through sustainability education. Secondarily, this paper discusses the core competencies required for the sustainability education and introduces our educational challenges.

The aim of sustainability education is to develop human resources with different specialties who, from various social backgrounds and various perspectives corresponding to their individual situations, can share a long-term and comprehensive perspective toward the construction of a sustainable society. Through sustainability education, these human resources will be expected to work toward solving actual problems while building collaborative relationships with a broad diversity of actors.

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EFFECT OF COOPERATIVE LEARNING ON STUDENTS' UNDERSTANDING OF REACTION RATE

Özgecan Taştan (Kırık)

Çukurova University, Turkey

otastan@cu.edu.tr

Yezdan Boz

Middle East Technical University, Turkey

yezdan@metu.edu.tr

ABSTRACT

The purpose of this study is to examine the effect of cooperative learning on students' understanding of reaction rate in 11th grade chemistry course. 110 students participated in the study. The participants were selected from two different schools. Two classes from each school were included. One of the classes in each school was randomly assigned as a control group instructed by traditional way and the other as an experimental group instructed by cooperative learning. Reaction Rate Concept Test (RRCT) was given to measure students' understanding of reaction rate. In addition, Science Process Skill Test (SPST) was administered before instruction to decide whether there was a significant difference between two groups in terms of their science process skills. At the end of the instruction, there was a significant mean difference between the experimental and control group students' performances. According to the results of RRCT and interviews, cooperative learning removed most of students' misconceptions about reaction rate concept and so brought about a significantly better understanding of reaction rate compared to traditional instruction.

Keywords: *Cooperative learning, misconception, reaction rate*

INTRODUCTION

Abstract concepts are difficult for students to comprehend. Therefore, it is necessary to be aware students' misconceptions and develop proper teaching strategies having regard to them. Research studies indicated that students have great difficulties in understanding reaction rate. For example, Kousathana and Tsaparlis (2002) examined 17-18 aged students' errors while solving numerical-chemical equilibrium problems in an elective course. According to the results, majority of the students could not understand that reaction rate and reaction yield are different concepts and they are not directly related to each other. Many students expressed the following misconception: "*Rate of reaction means the same as extent of reaction*", that it is also supported by Griffiths (1994). Kousathana and Tsaparlis (2002) also concluded that students applied Le Chatelier's principle to rate of reaction concept. Several students thought that if the reaction is thermoneutral (neither endothermic nor exothermic) the rate of reaction is not influenced by a change in temperature in line with Le Chatelier's principle. There is a hidden misconception here: "*heat is evolved or absorbed only in the cases that heat is explicitly involved (that is, shown) in the chemical equation ("thermochemical" equation*) (p. 14).

In another study, Garnett, Garnett and Hackling (1995) investigated 17-19 years old students' understanding of chemical kinetics and found the following misconceptions:

- "The forward reaction rate increases as the reaction 'gets going'" (p. 81).
- "The forward reaction rate always equals the reverse reaction rate" (p. 81).
- "The forward reaction is completed before the reverse reaction commences" (p. 81).

Çakmakçı (2005) examined secondary school and undergraduate students' conceptual understandings of chemical kinetics. The study indicated that though most of the school students knew the factors affecting reaction rate (e.g. temperature, concentration, catalysts), many of them did not agree that volume or pressure are factors affecting rate of reactions in gas phase. Some students used the terms of concentration and number of moles interchangeably. A misconception held by students is the rate of a reaction is directly proportional to the concentration of reactants. They did not consider the order of the reaction. Other results showed that students could not interpret the graphs related to the factors affecting reaction rate. Also, they had difficulty in understanding the fact that the rate of a reaction must be determined experimentally.

Cooperative learning is a suitable strategy to deal with the misconceptions and improve students conceptual understanding of abstract concepts (Acar & Tarhan, 2008; Basili & Sanford, 1991; Slavin, 1987). It requires students to work together in small groups to support each others' learning and understanding and to accomplish shared goals. The research studies suggest that successful cooperative learning needs to provide following elements to increase students' efforts to achieve, and to improve their interpersonal relationships: positive interdependence, face to face promotive interaction, individual accountability, social skills and group processing (Johnson & Johnson, 1975; Johnson, Johnson, Holubec & Roy,1990). When *positive interdependence* is obtained, students will understand that each member's contributions are crucial and each member has a unique contribution to help the group achieve its goals. *Face to face promotive interaction* exists when students work in small groups where they can see each other so that they can engage in face-to-face discussions about their tasks. *Individual accountability* implies that each group member is responsible for his/her own contribution, free-loading is not tolerated and everyone must contribute. For *social skills* to be established, students need to be taught how to communicate efficiently with each other to know how to express their ideas, acknowledge contributions of others, deal with discrepancies, and manage conflicts. *Group processing* is a kind of formative assessment including students' reflections on how they are managing the process of learning and what they may still need to do to reach their goal. Group members discuss how well they are reaching their goals and maintaining effective working relationships with each other.

Teachers can guide learning of students having different backgrounds by creating an environment in which they are actively involved in their learning. Cooperative learning, which is based on constructivism, is one of the proper methods satisfying this goal. When students work in cooperative groups, they more frequently use higher levels of reasoning and critical thinking skills to create new ideas and solutions compared to competitive and individualistic situations (Johnson & Johnson, 1999). Furthermore, Johnson and Johnson (1987) found out that when cooperative learning approach was used more in the classroom, students would learn science better, they would tolerate the differences more and value themselves more as science students.

Correspondingly, following research questions were investigated in the present study:

1. Is there a significant mean difference between 11^{th} grade students who are taught by cooperative learning and traditionally designed instruction in terms of their understanding in reaction rate when the effect of science process skills is controlled as a covariate?
2. What are 11^{th} grade students' conceptions about reaction rate?

METHODOLOGY

Sample

One hundred and ten 11th grade students were involved in the study since the concept of reaction rate was taught at this grade level. The students were from two different schools, one of which was a high school and the other was an Anatolian high school. Students of Anatolian high school were accepted to that school through a nationwide exam while the high school has no academic selection criteria; therefore, they were brighter than the students of high school. The researchers picked two classrooms randomly from each school since it was not possible to assign students to experimental and control group one by one randomly. One class was assigned randomly as experimental group and one class as control group in each school. Correspondingly, experimental and control group involved 56 and 54 students, respectively.

Two teachers, one in each school, taught related chemistry content. They had nine and 11-year-teaching experience and similar chemistry content background. Both teachers took experimental and control group.

Instruments

Reaction Rate Concept Test (RRCT)
RRCT, developed by the researchers, is composed 16 two-tier items and 7 multiple choice items in Turkish. A two-tier question involves two parts. First part includes three or four alternatives. In the second part, students are expected to provide their reason for the answer given in the first part by selecting among four alternatives. These alternatives are constructed based on students' misconceptions (Treagust, 1987). Therefore, the alternatives of the two-tier items and multiple choice items in RRCT were prepared by considering students' misconceptions revealed by some studies (Haim, 1989; Garnett et al., 1995; Nakiboğlu, Benlikaya & Kalın, 2002; İcik, 2003; Bozkoyun, 2004; Çakmakçı, 2005; Balcı, 2006; Kıngır & Geban, 2006). Each item was assessed by four chemistry educators and two chemistry teachers to check its content validity, accuracy, and format. The test covered rate of reactions chapter including reaction rate, collision theory, activation energy, heat of reaction, potential energy diagrams, reaction mechanisms, rate equations and orders and the factors affecting reaction rate (concentration, temperature, surface area, and catalyst).

It was piloted to 251 high school students who had already learned reaction rate concept, from different schools at 11th grade. Reliability coefficient of the test was found as 0,78.

RRCT was implemented to both groups as pre-test to control students' previous knowledge and post-test to measure students' conceptual understanding in the context of reaction rate.

Science Process Skill Test (SPST)
SPST, which was developed by Okey, Wise and Burns (1982), is composed of 36 multiple choice questions measuring five skills: identifying variables, operationally defining variables, identifying appropriate hypotheses, interpreting data and designing experiments. It was adapted into Turkish by Geban, Aşkar and Özkan (1992). The reliability of the test was found to be 0,85.

Science process skills contribute to students' achievement in education (Blosser, 1975). Brotherton and Preece (1995) stated that there is a close link between cognitive development and science process skills. Most of science misconceptions among secondary school students could be related to the lack of formal reasoning patterns such as the isolation and control of variables, probabilistic thinking, and the schema of proportion.

Science process skills cannot be separated from the conceptual understanding being involved in learning and applying science. Science process skills are means for understanding science and also major goal of science education. Science learning must engage students in activities which invite higher cognitive stage (Harlen, 1999). Therefore, it is necessary to control students' science process skills while investigating improvement in their RRCT scores. For this reason, SPST was administered to both groups before instruction in order to control its impact on students' understanding of reaction rate.

Interviews

Semi-structured interviews were conducted with 12 students from both groups and two schools to get deep information related to students' understanding of reaction rate. The researchers selected the interviewees depending on the students' post-RRCT results as low, medium and high achievers. Correspondingly, two low, two medium and two high achievers were chosen from each group. Interview questions were based on students' answers to RRCT. They were conducted individually for about 20 minutes.

Procedure

This study took 6 weeks of 2008-2009 fall semester in Ankara, capital city of Turkey. Before instruction, RRCT and SPST were implemented to both groups. In experimental group, Treatment Verification Checklist, developed by the researchers, was applied by one of the researchers and a PhD student majored in chemistry education to decide if cooperative learning method was implemented as intended. They observed the groups once a week and filled the checklist. At least 75% of the items were marked as "usually" and "yes" by two observers. The checklist indicated that many of expected characteristics of cooperative learning were satisfied such as, physical arrangement of the classroom (to permit face to face interaction); informing students about characteristics of cooperative learning, social skills expected from them and aim of group activities; heterogeneous groups; individual quizzes; rewarding successful group; involving all members in the activity and enough guidance and feedback by the teacher. The checklist was not used in statistical analysis. During the instruction, students worked on worksheets as a group cooperatively to reach instructional outcomes.

In traditionally instructed classroom, teacher taught reaction rate through discussion and lecturing. The teacher described and defined the concepts, wrote related chemical equations and key words on the board, students took notes, and after teacher's explanations, the concepts were discussed through teacher-directed questions. Teacher sometimes used analogies and daily life examples to make some points more concrete since reaction rate is an abstract topic of chemistry. The instructions in control groups were observed to ensure that similar contents with experimental group were covered and similar teaching strategies in control groups of both schools were used by two teachers. The observers reflected that most of the students were passive listeners and note takers and student-student interaction was not allowed. Similar questions and content were covered in the control group as in cooperative learning class. On the other hand, teacher didn't consider students' misconceptions or their existing knowledge during instruction. He was the center of the classroom and the students listened to him quietly during the lesson.

Analysis

Previous to treatment, independent-samples t-test was conducted by using Statistical Package for Social Sciences to determine whether there was a significant mean difference between experimental group and control group in terms of SPST and pre-RRCT scores. One-way ANCOVA was used for the analysis of post-RRCT scores to reveal the effect of cooperative learning on students' understanding of reaction rate. Students' scores on SPST were assigned as covariate.

FINDINGS

The results of analysis of post-RRCT scores indicated that there was no significant mean difference between the groups with respect to previous reaction rate concept understanding measured by pre-RRCT, $t(108) = -0.272$, $p > 0.05$. On the other hand, there was a significant mean difference between them with respect to science process skills measured by SPST, $t(108) = 2.59$, $p < 0.05$. As a result, SPST was assigned as covariate in the analysis of post-RRCT scores.

After meeting the assumptions, one-way ANCOVA was conducted, in which SPST scores was assigned as covariate. Descriptive statistics for pre-RRCT, SPST and post-RRCT scores of the students of both groups is given in Table 1.

Table 1. Descriptive Statistics for Pre-RRCT, SPST and post-RRCT

Group	N	Pre-RRCT		SPST		Post-RRCT	
		Mean	SD	Mean	SD	Mean	SD
EG*	56	8.66	3.58	23.10	3.84	18.82	3.28
CG**	54	8.83	3.03	21.20	3.83	15.87	3.46

* Experimental Group
** Control Group

The results for analysis of post-RRCT scores indicated that there was a significant mean difference between the groups in terms of students' understanding of reaction rate concept. In other words, cooperative learning caused better results in terms of coping with students' misconceptions about reaction rate compared to the traditional instruction. Table 2 presents ANCOVA results.

Table 2. Results of One-way ANCOVA

Source	df	F	p	Partial □^{2}
SPST	1	28.23	0.00	0.20
GROUP	1	13.59	0.00	0.11

Partial □^{2} of 0.11 means that there is almost a large relationship between treatment and dependent variable, referring that the magnitude of the difference among groups was nearly large (Kittler, Menard & Phillips, 2007). This means that, 11 % of variance on dependent variable was attributed to treatment. In the same way, partial □^{2} of 0.20 suggests a strong relationship between treatment and covariate. That is, 20 % of variance, which is a large value, on dependent variable was explained by science process skills of the students. Therefore, the effect of science process skills of students on their understanding in reaction rate concept cannot be underestimated. It is necessary to consider students' science process skills while investigating their conceptions or achievements in science.

To sum up, cooperative learning led to better results in terms of dealing with students' misconceptions about reaction rate compared to the traditional instruction.

Interview results

Six students from experimental group and six students from control group were selected depending on their scores of post-RRCT for the interviews. Some of the interviews were discussed here because of the page limitations.

Students' ideas about reaction rate

Although most of the students knew that rate of a reaction is calculated by measuring amount of substance consumed or produced per unit time they still had some misconceptions concerning what reaction rate is. Students in both experimental and control group did not have an accurate definition of reaction rate in their minds. Following misconception was detected in students of control group: *forward reaction rate* + *reverse reaction rate* = ΔH. Furthermore, some students had the misconception that r*eaction rate is the time necessary for a reaction to be completed* which was also identified by Kousathana and Tsaparlis, (2002); Nakiboğlu, et al., (2002); İcik (2003) and Çakmakçı (2005).

Change of Reaction Rate with Time

The interviews showed that most of the experimental group students understood how rate of reaction changes with time depending on the concentrations of reactants and they could be able to interpret what they knew on the related graph. On the other hand, control group had great difficulty in understanding change of rate with time and they had also problems with interpretations of related graph. They confused the rate of one-way reaction with the rate of equilibrium reactions during the reaction proceeds. Some students had the misconception that *the rate of the reaction increases at the beginning of the reaction; when reactants are consumed, the reaction rate drops, and at the end of the reaction, the rate becomes zero*, which was also found out by Çakmakçı (2005). In addition, some of them stated that *the rate of the reaction increases with time because the amount of products increases* as also supported by the study of Garnett et al., (1995) and Çakmakçı (2005). Similarly, some students from control group had the following misconception: *rate of a reaction is zero when it is at equilibrium.*

Zero-order reactions

The dialogues related to zero-order reactions indicated that students in experimental group had better understanding of zero-order reactions than the students in control group did. During the interview, a student from control group claimed that *rate of a zero-order reaction increases with time if the "kinds" of products increase*. Another student claimed that *if the reactants of a zero-order reaction were in gas phase, they would be written in the rate equation*. She also had the misconception that *if a gaseous reaction is heated, the rate of the reaction will increase, however, if reactants which are in solid phase are heated, the reaction rate will remain constant during the reaction.* Another misconception revealed by this interview was *rate constant (k) depends on temperature, concentration, and volume of the reactants.*

Effect of Surface Area on Reaction Rate

The interviews related to the effect of surface area on reaction rate showed that students in experimental group had better understanding. They comprehended that increasing surface area increases the number of collisions so the reaction rate increases by interpreting on the visual representations of the reaction vessels. Conversely, control group students had some misconceptions. For example, some students stated that *powdered sugar melts faster than the cube one in tea.* They confused melting with dissolving. They also compared this physical event with a chemical reaction to find out the effect of surface area on reaction rate. A student had the misconception that *crumbled substances move and so react faster than a big piece of a substance.* As a result, students in control group failed to reason their answers.

Effect of Concentration on Reaction Rate

Students in experimental group could interpret a curve related to the effect of concentration on reaction rate. They could conclude that the reaction in which the biggest amount of product formed per unit time is the fastest one. On the other hand, control group students had great problems with interpreting the curve. Most of them deduced that *faster reaction produces more products.* When they were asked the effect of concentration on reaction rate, they could easily answer the question. However, they could not make interpretations on a curve by using this information.

Effect of Temperature on Reaction Rate
Most of the students in experimental group could make correct interpretations on a curve which is related to the effect of temperature on reaction rate. They also could reason their answers. However, a student in experimental group had the misconception that *the higher the temperature is, the more the amount of products formed is*, which was also revealed by the study of Kousathana and Tsaparlis, (2002). On the other hand, experimental group students could reason their answers better than control group students could.

Effect of Catalyst on Reaction Rate
The interviews indicated that students in both groups understood the effect of catalyst on reaction rate. They could use their information to interpret the curve related to the effect of the catalyst on reaction rate. However, a misconception was detected in control group, *catalyst gives energy to the reaction and so increases the activation energy and the rate of the reaction* as supported by Çakmakçı (2005). Another misconception was that *catalyst increases the average speed of molecules* as also identified by Kıngır and Geban, (2006).

DISCUSSION AND CONCLUSION

The main purpose of the present study was to investigate the effectiveness of cooperative learning on 11th grade students' understanding of reaction rate concept. According to the results, cooperative learning resulted in significantly better acquisition of knowledge related to reaction rate and elimination of misconceptions than the traditional instruction. Effectiveness of cooperative learning was also supported by other studies in the literature (e.g. Felder, 1996; Barbosa, J´ofili & Watts,2004; Bilgin & Geban, 2006; Doymuş, 2007; Acar & Tarhan, 2008). In addition, post-RRCT results and the interviews indicated that experimental group students performed better in RRCT and they could provide better reasoning for their answers. However, some of the misconceptions could not be removed in both groups after the instruction. The most frequent and persistent misconceptions, revealed by Reaction Rate Concept Test and the interviews, in consistent with the previous studies (Haim, 1989; Garnett et al., 1995; Nakiboğlu et al., 2002; İcik, 2003; Çakmakçı, 2005; Balcı, 2006; Kıngır & Geban, 2006) are as follows:

- Reaction rate is the amount of substance turning into products per unit time at constant temperature and concentration.
- Students overgeneralized that rate of reactions always decreases as the reaction proceeds without considering the order of the reaction.
- Catalyst increases reaction rate without changing mechanism.

In addition to these, interviews revealed some new misconceptions which are given below:
- Forward reaction rate + reverse reaction rate = ΔH
- Rate of a reaction is zero when it is at equilibrium.
- Rate of a zero-order reaction increases with time if the "kinds" of products increase.
- If the reactant of a zero-order reaction was in gas phase, it would be written in the rate equation.
- If a gaseous reaction is heated, the rate of the reaction will increase, however, if reactants which are in solid phase are heated, the reaction rate will remain constant during the reaction.
- Rate constant (k) depends on temperature, concentration, and volume of the reactants.
- Crumbled substances move and so react faster than a big piece of a substance.
- Particles in lower volume have greater speed than the ones in higher volume.

These results supported the idea that misconceptions are persistent even after the instruction different from traditional way (Novak, 1988). If the teacher does not cope with them, they will distort students' further learning.

In the present study, science process skills of the students explained a significant portion of their conceptual understanding in reaction rate. Essentially, science process skills accounted for 20 % of variance on dependent variable. Therefore, effect of science process skills of students on their conceptions of reaction rate cannot be ignored. That is to say, science process skills of participants should always be considered while investigating their conceptions or achievements in science.

To sum up, contributing to progress of science learning is a sore process. Student-centered methods which provide students with construction of their own knowledge require more efforts than teacher-centered methods. However, teaching strategies where the students are actively involved in their learning process like cooperative learning promote meaningful learning.

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HOW TO SET A GOOD EXAMPLE TO PUPILS? TEACHERS' PURPOSE IN LIFE AND BEHAVIORAL INTENTIONS TO PROTECT NATURE

Gregor Torkar

EGEA, Institution for nature,
Tacenska cesta 135a, 1133 Ljubljana, Slovenia

gregor.torkar@guest.arnes.si

ABSTRACT

Educational programs can provide more than just information; they can enrich a learner's values, build skills and offer positive environment for practising nature-friendly behaviours. Our main interest was studying teachers' behaviour towards nature protection. Teachers in primary schools often influence pupils' attitudes towards science subjects and are also role models in pupils' formation of environmental attitudes. We investigated how teachers' behavioural intentions are influenced by the degree of their purpose in life and by different teachers' professions. A study was conducted on a sample of 341 Slovenian teachers. Behavioural intention questionnaires and Purpose in Life test were used to measure the dependent variables. We found a teacher's purpose in life has a positive impact on behavioural intentions to take public and private actions to protect nature. There were also some indications that more environmentally educated teachers (biology and science teachers) express higher preparedness for nature-friendly behaviours, but not in all cases the differences were statistically significant. From the results we can conclude that in addition to teacher training, personal traits are also important for future development in environmental education. Therefore, some improvements in teacher's development are suggested that would lead to more effective environmental education.

Keywords: teacher, nature protection, behavioural intentions, purpose in life test, professional development, personal development

INTRODUCTION

Environmental Education

Humans have been learning about the natural world and teaching each other what they learn for thousands of years. The depictions of horses, lions, rhinoceroses, and other animals at Chauvet-Pont-d'Arc cave in France and other Paleolithic artwork indicate an intimate knowledge of the natural world. The human ability to learn about the natural world and apply what is learned has been a key factor in human dominance as a species (Hayes 2008). Our present-day view of the nature and learning is much more complex and the level of influence on the natural environment has long outgrown cave paintings and reached global dimensions. Among the international scientific community there is a widespread consensus that global warming is happening and that its causes are also anthropogenic (Selby 2007). As global economies and human population grow and as development expands, social conflict over natural resources will inevitably increase in the coming years (Manfredo 2008). The majority of the world's population is being urged to accept the modern idea that "everything that can be made must be made, and then sold" and that this view of everyday reality is being "unshakably structured by the omnipotence of technoscientific truth and the laws of the market" (Berthoud 1992, p. 71).

The need for improved education about the environment grows as conflicts over natural resources increase (Jacobson et al. 2006). The concern for environment is becoming a more and more significant issue nationally and internationally. The principal goal of environmental education is to raise environmental awareness and to improve environmental knowledge among learners. But is this enough? Knowing about something does not necessarily mean caring or doing anything about it. Programs that simply provide information often do not lead to hoped changes, except where the lack of information is a significant barrier to environmental behaviour (Schultz 2002). The good news is that educational programs can provide more than just information; they can enrich learner's values, build skills and offer a positive environment for practising new nature-friendly behaviours (Leal Filho 1995, Schultz 2002).

Kates et al. (2001) argue that many environmental problems do not lend themselves to analysis by the conventional, rational approach of defining the problem, collecting data, analyzing data, and making decision based on the results. Environmental education not only criticizes conventional science itself, but current science education practice as well (Korfiatis 2005, p. 236). This criticism focuses on those educational approaches which fail to acknowledge that no science teaching can avoid communicating messages about how we humans look upon and treat nature (Korfiatis et al. 2004) and that these messages influence attitudes towards nature (Brackney and McAndrew 2001). Those educational approaches promote teaching science as value-free knowledge, without seeking deeper understanding of the destructive and hegemonic role of modern science, as well as of its conceptual, social, cultural and moral background (Ashley 2000, Hart 2002). On the contrary, environmental education strongly supports the position that knowledge is socially constructed, that there are cognitive, economic, moral and philosophical aspects to be considered and that there are no certainties in theory or in practice (Selby 2007). It also seeks to develop critical skills needed for informed personal decisions and to empower people to take action on environmental issues (Dillon and Scott 2002, Hart 2002).

Envrionmental Behaviour and Teacher's Role

Chawla and Flanders Cushing (2007) explained that the background of action is much more complex than knowledge alone and they raised an important question: "What kinds of actions most effectively address environmental problems?" They emphasised that it is not enough for environmental education to promote individual private actions for the environment. Environmental education needs to emphasize the most strategic actions. Stern (2000) distinguishes "private sphere" and "public sphere" environmentalism. Measures of responsible environmental behaviour in environmental education research have typically focused on private actions (turning off unneeded lights, recycling, composting, green purchasing etc.) (Chawla and Flanders Cushing 2007), but is this all education can do? If we wish to solove world's most serious environmental problems, such as climate change, only taking (educating for) private actions without collective public change, built on many-sided and many-levelled approach (education), will not be enough. Chawla and Flanders Cushing (2007: p.438) said: "If environmental educators confine themselves to fostering private sphere environmentalism, they may in fact be leading students astray."

Our main interest was studying teachers' behaviours towards nature protection, because teachers in primary schools influence pupils' attitudes towards science subjects (Lederman 2008) and they are often role models in pupil's formation of environmental attitudes (Chawla 1998, 1999, Chawla and Flanders Cushing 2007). Chawla (1999) finds that environmental teachers are expected to prepare students to be successful citizens as well as leaders who will be able to take affirmative environmental actions. Teacher's personality is obviously one of very important factors that influence pupil's environmental attitudes and behaviours or as Dewey (1997) said: "Example is more potent than precept; and a teacher's best conscious efforts may be more than counteracted by the influence of personal traits which he is unaware of or regards as unimportant." Demirbolat (2006) suggested that a teacher's values are more influenced by factors like personal attributes and the environment in which person grew up, than the programmes that educate teachers. We intend to find out how teachers' different professions influence their behavioural intentions towards nature protection.

We have explored teachers' behavioural intentions and not actual behaviours. Sometimes certain behaviours aren't practiced despite someone's strong will. Behavioural theories, such as the theory of planned behaviour (Ajzen 1991), emphasise the role of behavioural intentions to be the most immediate and important predictor of behaviour. Intentions are explicit decisions to act in a certain way, and they concentrate on a person's motivation towards a goal in terms of direction and intensity (Sheeran 2002). The behaviour should be easily accessible or in other words, it is easier to achieve change if the practical conditions exist to support the behaviour (Ryden et al. 2003). Studying someone's behavioural intentions can give us insights into their preparedness for actual behaviour. Studying intentions instead of actual behaviour helps exclude external barriers to performing desired behaviours. Respondents decide solely on the basis of their own values and attitudes, regardless of whether the actual circumstances permit the realization of behaviour.

Teacher's Purpose in Life

In the article we focused our attention on Viktor Frankl's Logotherapy. He (1987) wrote that every individual has an innate desire to develop a purpose in life, which he termed "will to meaning". He says that a purpose in life is innate for any human being and is a basic human need in the development of a person's spiritual dimension which is composed of values, meanings, freedom and responsibility. This dimension offers to each individual the ability to identify and assess meaning of life decisions in a given time position.

Viktor Frankl (1973) gave a general guide how to find meaning and that requires a certain attitude towards the world. Frankl (1973) wrote: "We must perform a kind of Copernican Revolution, and give the question of the meaning of life an entirely new twist. To wit: "it is life itself that asks questions of man… it is not up to man to question; rather, he should recognize that he is questioned, questioned by life; he has to respond by being responsible; and he can answer to life only by answering for his life." (p. 62) This phenomenological attitude is an openness of mind free from personal interest. It is directed towards the essence of the situation that allows one be reached or even captured by the situation. If the essence of a situation is valuable in itself, is seemingly perfect and cannot be made better than we are left to enjoy, admire and simply experience (Längle 2003). According to Frankl (1987) we can discover the meaning in life by doing a deed (creative work), by experiencing a value (nature, art, music) and by suffering (the stand we take in situation of unavoidable tragedy). The aim of the Logotherapy is enabling a person to experience his or her life freely at the spiritual and emotional levels, to arrive at authentic decisions and to come to a responsible way of dealing with themselves and the world around them (Längle 2003).

Complex way of thinking is necessary not only for teachers and their integration of teaching content. It is crucial to equip students with this complex way of thinking and cooperative learning that will help them face and resolve complex environmental problems. Logotherapy can teach us an important lesson. Frankl (1987) said that logotherapy is neither teaching nor preaching. It is as far removed from logical reasoning as it is from moral exhortation. To put it figuratively, the role played by a teacher is rather that of an eye specialist than of a painter. Frankl (1987) postulated that the life of a responsible human being is oriented to somebody or something (for example: nature, creative work, art) outside him- or her-self. He called this human ability a self-transcendence and saw it as a way of finding personal meaning in life. Previous empirical studies support that human values of self-transcendence have positive impact on attitudes, behavioural intentions and self-reported behaviours toward environmentalism (see Karp 1996, Schultz et al. 2005, Torkar 2009). The role of a teacher is to motivate learners to experience their life freely to arrive at authentic decisions; to come to a responsible way of dealing with the world around them. Frankl clearly considers Logotherapy to be valuable to the quest for wisdom. It is through the creation of this meaning that individual can experience wisdom and understanding.

Based on Frankl's theory, Crumbaugh and Maholick (1964) developed the Purpose in Life (PIL) Test. In the published research about the PIL, having a sense of purpose in life clearly contributes to establishing positive characteristics, strong values, and healthy mental attitudes. The PIL has been used widely in clinical and outpatient contexts in clinical psychology. Studies have proven PIL's effectiveness in determining levels of occupational meaningfulness (Crumbaugh 1968) and lesser degree of purpose among prison inmates (Reker 1977). Studies have shown that those with higher meaning in life suffer less anxiety and have greater self-confidence (Yarnell 1971, Reker 1994), self-acceptance (Crumbaugh and Maholick 1969), work motivation (De Klerk 2001), happiness and life satisfaction (Compton 2000), and social attitudes (Pearson and Sheffield 1975). They also experience greater satisfaction with their lives (Reker and Cousins 1979), have more positive expectations of the future (Reker and Cousins 1979), and enjoy increased emotional stability (Crumbaugh and Maholick 1969). Molasso (2006) found that colleague students who are spending more time with friends, studying, exercising, attending parties and social events, working on campus, an interacting with faculty outside of the classroom have more positive sense of purpose. However, while there is rich research on the PIL, no study on the PIL specifically with environmental education or behaviour issues was identified. Therefore, we focused our attention on a question how a teacher's purpose in life influences his or her behavioural intentions to protect nature.

METHODOLOGY

The study was conducted on a sample of 341 teachers working in Slovenian primary schools (n = 118 kindergarten teachers, n = 118 elementary school teachers, n = 105 biology and science teachers). The sample included 3 males and 338 females. Most were 40 to 45 years old. Although these teachers do not comprise a random sample representative of the Slovenian population, there is no reason to believe that the sample represents any particular bias other than gender. In fact, most educators in Slovenia are female, which was also the case in this sample.

A Behavioural Intention Questionnaire (BIQ) with 9 items and a Likert five-point scale (from 1 = strongly disagree to 5 = strongly agree) was designed for the study. Based on Viktor Frankl's (1959) theory, Crumbaugh and Maholick (1964) developed the Purpose in Life (PIL) test with 20 seven-point scale items to measure the degree of teacher's purpose in life. The range of total scores for PIL test was 20–140.

The BIQ mean score and total PIL test score were calculated. PIL test scores were classified into three groups using K-Means Cluster Analysis. Behavioural intention items were submitted to factor analysis with Varimax rotation and three factors with eigenvalues greater than 1.0 derived. Factors were termed "taking public actions" (3 items, α = .66), "taking private actions" (4 items, α = .62) and "contributing money" (2 items, α = .78) for nature protection (Table 1). These three factors explained 62.3 % of the total variance. In order to examine how a teacher's profession and sense of meaning influenced their behavioural intentions towards nature protection, an analysis of variance test was used to analyze the data. A teacher's profession and the PIL test cluster were defined as independent variables, and the behavioural intention factors as dependent variables. Finally we used Pearson's product moment correlation coefficient for exploring the relationship between behavioural intentions and the PIL test score.

Table 1. Factor analysis (with varimax rotation) for BIQ items

	Factors		
	Taking public actions	Taking private actions	Contributing money
I am prepared to attend a seminar or workshop aimed at deepening the knowledge about nature protection.	,639		
I am prepared to attend activities (work campaign, research...) for nature conservation.	,773		
I am prepared to join an organization which advocates the nature protection.	,804		
I am prepared to support the increase in taxes if the money thus obtained is used for nature conservation.			,867
I would give part of my income if I am convinced that this money will be used for nature conservation.			,873
I am prepared to use more public transport and bicycle, in order to reduce air pollution.		,460	
I am prepared to sign a petition that calls for the protection of nature.		,481	
I am prepared to save electricity.		,849	
I am prepared to recycle paper and other waste in the household.		,812	
Eigenvalues	3,092	1,463	1,052

RESULTS AND DISCUSSION

The mean score for BIQ items was 3.95 (SD = .46). The result indicates that Slovenian teachers were generally quite keen to adopt behaviours that protect nature, but not all suggested behaviours got the same level of support. Teachers were more prepared to take private actions for nature protection (x = 4.26, SD = .45) than to take public actions (*x* = 3.89, SD = .58) or to contribute money (x = 3.45, SD = .89). Chawla and Flanders Cushing (2007) emphasised that it is not enough for environmental education to promote private actions and that environmental education needs to emphasize the most strategic actions. The results are not encouraging, because teachers were considerably less prepared for the public conservational activities. Slovenian Teacher's important role in the classroom (Chawla 1998, 1999, Chawla and Flanders Cushing 2007) would certainly require more community oriented and insightful defenders of nature protection.

A one-way ANOVA was used to test differences between groups of teachers of different professions on their behavioural intentions to protect nature. Teachers' different professions significantly influenced their intentions to take public actions for nature protection ($F_{(2,328)} = 6.846$, $p < .05$) and willingness to contribute money for nature conservation ($F_{(2,309)} = 9.328$, $p < .001$), but there were no significant differences in intentions to take private actions ($F_{(2,334)} = 2.399$, $p > .05$). Tukey post-hoc comparisons of the three groups indicate that that there is a significant difference in preparedness to take public action for nature protection between elementary school teachers (*x* = 3.76, *SD* = .60) and biology teachers (*x* = 4.05, *SD* = .56) in favour of the later, *p* = .001. Elementary school teachers (*x* = 3.20, *SD* = .87) were also less prepared to contribute money for nature protection than biology teachers (*x* = 3.71, *SD* = .82), *p* < .001. Comparisons between other groups were not statistically significant at p < .05. Results show that more environmentally educated teachers (biology and science teachers) express higher preparedness for nature-friendly behaviours, but not in all cases the differences were statistically significant. No statistically significant differences were found between kindergarten and biology teachers, what indicates that also other variables could be important.

A one-way ANOVA was used to test how a degree of purpose in life influences on behavioural intentions to nature protection. The results of the Purpose in Life (PIL) Test (Crumbaugh and Maholick 1964) show some significant influences. Behavioural intentions to take public actions ($F_{(2,337)} = 7.784$, $p < .001$) and private actions ($F_{(2,337)} = 6.626$, $p < .05$) for nature protection were significantly influenced by a teacher's purpose in life. No significant influence was found for the money contribution factor ($F_{(2,337)} = 1.560$, $p > .05$). Teachers that find their life highly meaningful were the most prepared to take public and private actions for nature protection.

Links between BIQ mean score and the PIL test total score were tested by using Pearson correlation coefficient. The correlation between the BIQ mean score and the PIL test total score is statistically significant (Figure 1). Teachers having a higher sense of purpose in life were more prepared for environmental behaviours. The results clearly show that teachers who find their life highly meaningful are the most prepared to take public and private actions for nature protection and consequently have an important impact on science and environmental education, as suggested by Lederman (2008) and Chawla (1999).

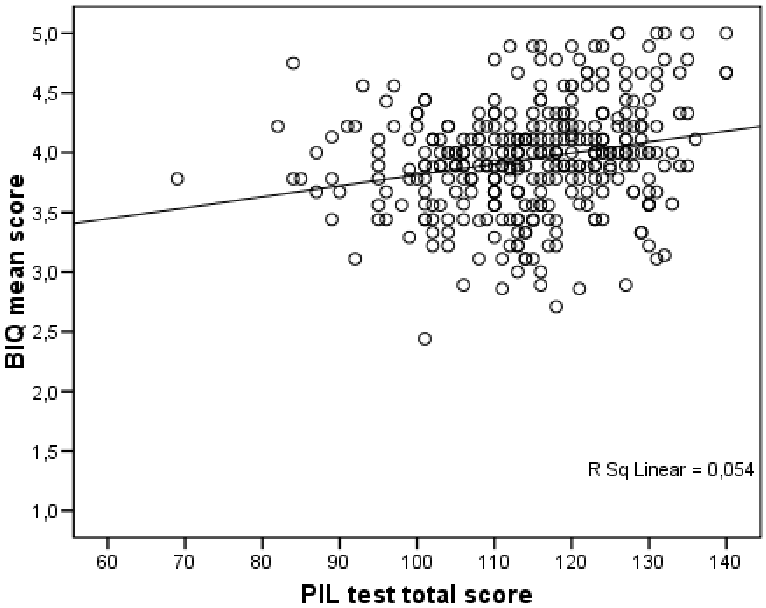

Figure 1. Relationship between the BIQ mean scores and PIL test total score ($r = 0.233$, $p < .001$, $n = 337$).

CONSLUSIONS

In the paper we presented an analysis of teachers' behavioural intentions by the degree of their purpose in life and by different professions of the teachers. Korfiatis et al. (2004) wrote that no science teaching can avoid communicating messages about how we humans look upon and treat nature. We agree with researchers, such as Chawla (1998, 1999), that a teacher can be a very important role model in shaping pupil's or student's attitudes towards nature protection. From the results gathered we can conclude that teacher's purpose in life and profession are important for predicting his or her behavioural intentions to protect nature. Teachers who find their life highly meaningful are the most prepared to take public and private actions for nature protection and consequently have an important impact on science and environmental education. Teachers, whose profession requires a better understanding of environmental issues, show some positive signs for the environmental behaviour, but it is still far from being as important as the purpose in life variable.

In conclusion, today is very difficult to offer pupils or students a relevant knowledge, skills and experience to benefit the lives of tomorrow. Therefore, teachers need constant in-service training to be keept informed about the development of environmental issues. But despite that, teacher's knowledge is often not sufficient to address environmental issues. A major challenge in the science of the last few decades is the recognition that nature is complex (Levin 1999). Science ecology and the field of applied ecology are in a shift from reductionism to a system view of the world, a shift to include humans in the ecosystem (Levin 1999). A single discipline cannot address the complex and changing environmental issues. Partnerships between different disciplines and societies are essential in order to integrate or generate a new knowledge. Teachers should be more open and responsible for cooperation and long-term partnerships. Partnerships should include dialogue among teachers of different scientific disciplines (natural sciences, social sciences and humanities) as well as with local community, NGOs, scientists and other groups of interest in order to generate new knowledge and ideas necessary to address complexity of environmental issues on local, national and global level.

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ECOCENTRIC EMPHASIS IN ENVIRONMENTAL EDUCATION SUBTOPICS (ECOSYSTEMS, POLLUTION AND USE OF RESOURCES) IN TEXTBOOKS OF 14 COUNTRIES

Rosa Branca Tracana

School of High Education
Polytechnic Institute of Guarda
Guarda, Portugal

rtracana@ipg.pt

Graça S. Carvalho

CIFPEC, Institute of Education
University of Minho
Braga, Portugal

graca@ie.uminho.pt

ABSTRACT

Two views of Human-Nature relation can be found: anthropocentrism and ecocentrism. In order to understand how school textbooks refer the human's position in nature we analysed how the axis of analysis "Human as guest *versus* Humans as owners of nature" is present in the three topics of environmental education – *Ecosystems, Pollution* and *Use of Resource* – in textbooks of 14 countries from Europe, Africa and Middle East. A specific grid of analysis, which was constructed in the context of a European Project BIOHEAD CITIZEN was used in this study. Results show that this axis of analysis is present in the majority of textbooks addressing the above three topics but not in the "*Biodiversity*" topic. Textbooks for 12-15 years old pupils were the ones having more occurrences than those for 6-11 or 16-18 years old. The textbooks present mainly an ecocentric position, whereas the aesthetic, ethical and cultural aspects are limited and inadequate, limiting the full perspective of education for sustainable development.

Keywords: *Environmental education, Human-Nature relation, Textbooks.*

INTRODUCTION

The understanding of the Human-Nature relationship affects strongly people's worldviews (Rehmann-Sutter, 2000) and differences in worldviews determine the way people conceptualize the need for addressing solutions of the existing environmental problems. As Esteves (1998) defends it is necessary to develop, in each of us and also in the Humanity, the sense of responsibility and solidarity through the environment.

Two perspectives of Human-Nature relation can be found: anthropocentrism and ecocentrism (Almeida, 2007). The former focuses in the relations between Humans and the Universe (Esteves, 1998) and confers humans' dominance over nature, where they, in the ecosystem, occupy the top of an alimentary chain. The latter aims at the ecosystem itself, where the humans are seen as elements of the biotic community having an attitude of respect for all the elements of that community (Almeida, 2007). It is easy to understand that these questions are not easy to solve but we have to have in mind ethical positions in order to solve the different environmental problems. It is also required a moral, ecological and economic perspective in the relation Human-Nature. This is to say that we need a change of attitudes in order to obtain a better world. In the sense of changing attitudes through the environment that surround us, in the sense of constructing a better world, it is pertinent the intervention of educative actions to make children and young people aware of environmental problems and promote positive attitudes and behaviours.

Textbooks analysis is seen as a major element in the evaluation of how the educational goals (at the legislative level of national programmes) are implemented at the school level where pupils must acquire knowledge, competences and develop appropriate values towards a sustainable environment (ME,1988). These textbooks are used by teachers with a double function: as a national programme (or syllabuses) guideline and as a didactical resource (Carvalho *et al*., 2009). Thus the textbook analysis turns out to be a relevant tool for studying socio-cultural determinants of environmental problems, in particular the school-related ones.

In order to understand how school textbooks refer the human's position in nature we analysed how the axis "Human as guest *versus* Humans as owners of nature" is present in the following topics of environmental education: *Ecosystems*, *Pollution* and *Use of Resource*.

METHODOLOGY

This work was performed by using specific parts of the grid of textbook analysis on the topic "Ecology and Environmental Education" constructed by the European FP6 STREP project BIOHEAD-CITIZEN (CIT2-CT-2004-506015) (Carvalho & Clément, 2007; Caravita *et al*., 2008). For the design of the grids of textbooks analysis, precise subtopics being exemplar of interactions between Science and Society, and challenges in Citizenship were chosen. They were: *Pollution, Use of Resources*, *Ecosystem and Cycles* and *Biodiversity*.

The corpus of this study was composed of 128 textbooks containing the topic *Ecosystems and Cycles*, *Pollution* and the *Use of Resources* in 14 countries involved in the European project FP6 BIOHEAD-CITIZEN CIT2-CT-2004-506015 (Carvalho, 2004): Cyprus, Estonia, Finland, France, Germany, Hungary, Italy, Lebanon, Lithuania, Malta, Morocco, Portugal, Romania and Senegal.

The above three topics were analysed in each country textbooks by the respective project teams by looking specifically to the axis "*Human as guest vs Humans as owners of nature"* in *Pollution*, *Use of Resources* and *Ecosystems and Cycles* (Tracana, 2009). The textbooks analysed were the ones more used in each country, and in some countries they only one textbook was used in schools. We looked for images and textual occurrences by using the grids of analysis. For each indicator we registered the images occurrences that appeared in the textbooks (Tables 1, 2 and 3). The problem of subjective interpretation in this kind of qualitative analyse, was controlled by having two analysts separately applying the grids and cross-checking the findings afterwards.

Table 1: Part of the *Pollution* grid related to *Human as guest* vs *Humans as owners of nature*

Content (Themes, topics)	Indicators	Page number of Images	Figure numer of Images	Occurence s in text
IMPACTS of POLLUTION				
	Impact on humankindkind *(only benefits and risks for humans)*			
	Economic consequences			
	Social *risks*			
	Aesyhetic values			
	Ethic, moral and cultural motivations *(e.g. future generations)*			
	Impact to ecosystem			

Table 2: Part of the *Use of Resources* grid related to *Human as guest* vs *Humans as owners of nature*

Content (Themes, topics)	Indicators	Page number of Images	Figure number of Images	Occurences in text
RESOURCE AVAILABILITY				
	Finite (limited) availability of resources			
	Infinite (unlimited) availability of resources			
	Renewable or non renewable resources, including food			
SUSTAINABILITY				
	Ecological sustainability			
	Social sustainability			
	Economic sustainability			
	Ecological-social-economic sustainability			
EQUITY				
	Resources distribution			
	Differences in distribution			
	Relevant factors for equity of distribution			
	Ecological conditions			
	Cultural conditions (knowledge, technology, education,..)			
	Ethical, moral norms			
	Economic conditions			
	Political decisions			
	International agreements			

Table 3: Part of the *Ecosystems and Cycles* grid related to *Human as guest* vs *Humans as owners of nature*

Content (Themes, topics)	Indicators	Page number of Images	Figure number of Images	Occurences in text
CONSERVATION and MANAGEMENT of NATURE				
	Motivation for Conservation **(Only if explicitly mentioned in the text)**			
	To preserve a source of aesthetic pleasure for humans			
	To prevent exhaustion of natural resources important for economy			
	To prevent ecological dis-equilibrium			
	To respect nature and all living beings			

A qualitative approach was used for textbooks analysis but quantitative analysis was also used wherever possible in order to be able to compare items among countries.

RESULTS AND DISCUSSION

The analysis of the textbooks showed that the axis "Humans as owner's *versus* Humans as guests of nature" appears in three subtopics of environmental education *Pollution, Use of and Ecosystems*, but not in *Biodiversity*. This absence can be due to the fact that this axis in *Biodiversity* is not considered so important. In other studies (Tracana, 2009) it was also found that little importance was given to *Biodiversity* in all textbooks as compared to the topic *Pollution* or the *Use of Resources.* It seems that textbooks refer the problematic of species extension but not in a deep manner. This is a curious aspect because today the media address constantly these problems and the school should also take these matters into account in order to contribute for a better citizenship.

This axis "Humans as owner's *versus* Humans as guests of nature" is present in the majority of textbooks. Those booksfor 12-15 years old pupils are the ones having more occurrences than those for 6-11 or 16-18 years old, in all the subtopics *Pollution*, *Use of Resources* and *Ecosystem and Cycles* as it can observe in Tables 4, 5 and 6.

In Table 4 we observe that the item *"Impact to ecosystems"* is the most referred one, followed by the *"Impact on humankind"*. This occurs, perhaps because they are the ones that have more impact in human life. The *"Aesthetic values"* and "*Ethic, moral and cultural motivations"* have residual presence, which means that the textbooks do not give importance to these issues.

Table 4: Textual occurrences of the *Human as guest* vs *Humans as owners of nature* in the subtopic *Pollution* in 40 textbooks

Textual occurrences	Pupils' age			Total
	6-11	12-15	16-18	
Impact on humankind	21	39	31	91
Economic consequences	4	6	14	24
Social risks	2	14	5	21
Aesythetic values	2	2	5	9
Ethic, moral and cutural motivations	0	7	2	9
Impact to ecosystems	51	72	67	190
Total	80	140	124	325

The aesthetic values are beauty values (Jeronen & Kaikkonen, 2002), and our results showed that they are poorly referred. Not only aesthetic but also ethic and cultural issues were found to be absent in the axis of *Human as guest vs Humans as owners of nature,* indicating that textbooks are not approaching appropriately the sustainability aim. This is a point which should be improved in the textbooks. According to Sachs (1993), to reach environmental sustainability it is necessary to consider simultaneously: *i) social aspects*, with the goal of reduce distance between life pattern of social groups; *ii) economical aspects*, made possible by an efficient allocation and management of the resources, much more under macros social criteria than micros social entrepreneurs and by regular flow of public and private investment; *iii) ecological aspects*, involving measures to reduce the resources consumption, and residual production, measures to intensify research, to introduce clean and resource saving technologies, and to define rules that allow an appropriated environmental protection; *iv) spatial aspects*, looking into a more balanced configuration of the rural-urban issue; *v) cultural aspects*, in order to get endogenous conceptions of involvement that respect the peculiarity of each ecosystem, each culture and each place.

Renewable or non renewable resources (Table 5) are more referred (42 occurrences) in the textbooks than the other items. This demonstrate that the textbooks are preoccupied to pass the information to pupils that the natural resources are not infinite, and they should be economically and rationally used. Torres (2007) claims that is important understanding that humanity must not dominate nature but interact with it. This is to say that nature should be used to attend not only the needs of this generation but also the subsequent ones. This leads to the importance of environmental education for the sustainable development.

Table 5: Textual occurrences of the *Human as guest* vs *Humans as owners of nature* in the subtopic *<u>Use of Resources</u>* in 31 textbooks

Textual occurrences	Pupils' age			Total
	6-11	12-15	16-18	
Resources, availability				
Finite (limited) availability of resources	3	15	9	27
Infinite (unlimited) availability of resources	3	2	5	10
Renewable or non renewable resources, including food	10	17	15	42
Sustainability				
Ecological sustainability	1	18	1	20
Social sustainability	–	3	–	3
Economic sustainability	–	5	2	7
Ecological-social-economic sustainability	1	9	7	17
Equity				
Resources distribution	–	–	–	–
Differences in distribution	14	11	1	26
Relevant factors for distribution equity	–	–	–	–
Ecological conditions	–	3	3	6
Cultural conditions	–	3	2	5
Ethical, moral norms	–	3	–	3
Economic conditions	1	3	13	17
Political decisions	–	3	–	3
International agreements	12	1	–	13
Total	45	96	58	199

For the analysis of humans in nature position as far as *resource availability* and *sustainability* are concerned, we observed that the textbooks transmit mainly an ecocentric position. However when looking at *equity*, the economic conditions is the most referred item, suggesting the societal importance given to economy in the goods distribution.

Table 6: Textual occurrences of the *Human as guest vs Humans as owners of nature* in the subtopic *<u>Ecosystems</u>* in 28 textbooks

Textual occurrences	Pupils' age			Total
	6-11	12-15	16-18	
To preserve a source of aesthetic pleasure for humans	4	7	2	13
To prevent exhaustion of natural resources important for economy	1	12	3	16
To prevent ecological dis-equilibrium	2	21	2	25
To respect nature and all living beings	35	9	3	47
Total	42	49	10	101

In the case of the subtopic *Ecosystems* we observed that the respect of nature and living beings was the item more referred. Once again the aesthetic aspect is the less considered.

These results show that textbooks in this analysis consider men as invited and not as owner of nature.

In conclusion, we can say that the textbooks from 14l countries, tend to defend the ecocentric perspective, where humans are seen as guest of nature and not its owner. Results also show that, in respect to this axis – “Humans as owner’s vs Humans as guests of nature” – the aesthetic, ethical and cultural aspects are inadequate, limiting the education for sustainable development. To reach the sustainability, it is necessary to look all together social, economic, ecological, spatial and cultural aspects (Sachs, 2001; 2004).

Further studies are going on to find out whether textbooks from groups of countries (Western or Eastern European countries and non European countries – African and Middle East countries) show specific tendencies in the way environmental education deals with the issue “Humans as owner’s *vs* Humans as guests of nature”.

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FAMILY SCIENCE AND TECHNOLOGY EDUCATION AS A NEW TEACHING AND LEARNING STRATEGY FOR ALL INCLUDING GIFTED STUDENTS

Josef Trna

Masaryk University, Czech Republic

trna@ped.muni.cz

Eva Trnová

Masaryk University, Czech Republic

trna@ped.muni.cz

ABSTRACT

Family science and technology education is an innovative teaching and learning strategy for children and adults. Family science and technology education is defined as expanding science and technology knowledge and skills from the school into the homes of students. Innovative educational goals of this strategy are evidently lifelong education of adults, but also strong motivation for children for science and technology education. This strategy induces a set of special educational methods, techniques and instruments. Hands-on experiments and activities based on simple equipment that can be found in most homes play a very important role. From the pedagogical constructivist point of view it is important to select and shape these educational activities to be suitable for families. The appropriate educational contents are daily lives. The combination of human body phenomena and hands-on activities results in motivation for children and adults. Family science and technology education also helps to identify and to develop those students gifted in science and technology. This presented research of the family science and technology education opens a new dimension of science and technology curriculum opportunities, teaching and learning strategies, and it demands development of special curricular materials.

Keywords: *Family science and technology education, hands-on experiments, lifelong education, motivation in science and technology education, daily and safe living.*

1. INTRODUCTION

Science and technology (S&T) education is becoming lifelong education. The reason is the rapidly growing number of new applications and the expanding knowledge in S&T. The fact that S&T knowledge and skills gained in school do not satisfy the necessities of life anymore could result in negative attitudes towards S&T. Many adults are gradually losing touch with current S&T knowledge and skills, and sometimes do not understand how new appliances work, which is why they prefer not use them.

Parents and grandparents are often unable to help students with homework, because they do not understand the educational contents. This negative attitude might be transferred from parents and grandparents to their children, which can cause lack of motivation in the students to study S&T. Pedagogical research should focus on the problem how to reverse this negative trend. Science teachers are looking for motivational teaching techniques which would help to eliminate a negative attitude toward S&T (Trna & Trnová, 2006a). Combination of these cognitive motivational teaching techniques can strongly increase motivation of students.

The cognitive motivation of students has a positive advantage, but using just this type of motivation is not enough. It is not possible to ignore social and achivement motivation that are developed in the social and family environment (Bransdorf, 2000). Research into social and achivement motivation of students uncovered the significant influence of family (White, 2007). Students themselves indicate their families and especially parents as the most important factors effecting their decisions. Foskett and Hesketh (Foskett & Hesketh, 1997) found that parents are the main stimulus in the process of students' continued educational development. According to Anderson (Anderson, 2004) parents are not only the most often sought out consultants for students, but they are also regarded as the most effective source of advice and information. Sociologist Matějů (Matějů, 2005) indicates that the influence of family in the Czech Republic on the students choice of profession and on career attainments is the most extreme in Europe. The student's family is the key motivational factor, especially during the primary school age. A family's positive attitude toward S&T can affect the student's inclination toward S&T education. This student results in S&T can be appreciated by the family. Such parents might buy S&T toys and kits, take science trips, enrol student in informal S&T activities, etc.

Our research and experience brought us to develop an innovative educational strategy called Family S&T Education (FS&TE). This type of educational strategy is implemented by the transfer of knowledge and skills from the school setting to families. Students who do FS&TE at home have the potential to inspire their siblings, parents and grandparents. We believe that FS&TE is an efficient educational approach, which nevertheless requires several conditions to be met. FS&TE could become a significant and effective part of parents' and grandparents' lifelong education. As it is a by-product of formal school education, it does not demand any additional financial costs. FS&TE can also help members of the older generation to acclimate to new products and information that they might otherwise not understand.

FS&TE could help in school education and also in improvement of student's giftedness for S&T. The influence of family and school on development of student's giftedness is widely recognized. Socio-culturally oriented models of giftedness are based on the assumption that giftedness can be realized only in the appropriate interaction between personal and social factors. According to the best-known model: Tannenbaum´s model (Tannenbaum, 1983), the family, together with peers and school, determines the development of student's giftedness. FS&TE is entirely consistent with Tannenbaum´s findings about the family's influence on the motivation of gifted students. The interaction of two very important factors, family and school, can be a very strong motivational stimulus for the development of a student's giftedness.

We discovered a relatively strong link between school science education and FS&TE. A family can investigate the use of FS&TE or encourage the adoption of this by the school to further develop a student's giftedness. FS&TE can be one of the environmental factors mentioned by Gagné (Gagné, 1991) which can significantly influence the development of giftedness. In accordance with his findings (Gagné, 1991) we can say that the family is the key factor, especially during the primary school age. If a gifted student is surrounded with a family who has a positive attitude toward S&T, this environment will affect the student's inclination toward S&T education. The family support in the form of school performance awards and extracurricular activities may cause that a latent giftedness can be manifested (Karnes & Shwedel, 1982). A student may have potential to demonstrate latent giftedness in the future, but opportunities must be available to manifest this giftedness. FS&TE could be an appropriate opportunity.

FS&TE requires interesting educational contents based on using relevant knowledge and skills from a student's everyday family life. Our pilot study shows the existence of such suitable educational contents for FS&TE, which will be described bellow.

2. RESEARCH AND RESULTS

The appropriate contents used in FS&TE are from our daily lives. These contents include (Trna & Trnová, 2008):

- The human organism: Students deal with the parameters of the human body which can be expressed by means of quantities, units and laws. Also external conditions are very important for the preservation of vital functions of the human organism including health.
- Home, entertainment, sports etc: Students can be motivated by explanation of the usual subjects and phenomena from everyday life such as heat and light sources, means of transport, audiovisual techniques, chemical agents, domestic plants and animals etc. Information about the economical and ecological aspects in everyday living is growing more and more important.
- Safety risks: Protection against negative extraneous influences on the human organism and information on safe behaviour in transport, at work etc.

The human organism is a very interesting object for students and adults. FS&TE involving new medical information can help in the prevention and diagnosis of certain diseases or risks. The important theme is life protection against dangerous influences, which include the fast change of speed, effects of forces, temperature fluctuations, radiation etc. Another important advantage of teaching and learning about the human organism is that teaching aids are not needed because everyone has a body.

The combination of appropriate contents and hands-on activities results in motivation for students and adults. Human body experimenting and measuring are good motivation for students and adults as well. Many human body parameters such as temperature, weight, blood pressure, body mass index, etc. can be measured by students and adults using simple instruments in their homes. Prevention of at-risk factors is based on these human body measurements and potential health risks can be diagnosed with the assistance of these simple hand-on activities.

We undertook the research of educational efficiency of these activities in FS&TE. To prove the effectiveness of this educational strategy for students of different ages, we conducted research in a primary school and then in a lower secondary school. We used the educational contents of human body measurement.

2.1 Flat foot

We used the measurement of flat feet for our research of students in primary school (Trna & Trnová, 2006b). The research of the effectiveness of FS&TE was carried out twice (in 2006 and 2009). One hundred students in the fourth grade in primary science lessons were taught how to measure flat feet.

Students' knowledge background:
The foot structure is very important for various movement conditions of the body. The most known disorder is flat feet caused by fallen arches. Inappropriate footwear is a large contribution to this disorder. That's why the length and width of the foot is important when buying the correct shoes.

Students' hands-on activity:
Paint the sole of the foot with water (oil, ink etc.) and step on suction paper. Use a ruler to measure the widest (w_1) and narrowest part (w_2) of the footprint (Figure 1). Calculate $I = w_2 / w_1$. Evaluate results using the Table 1.

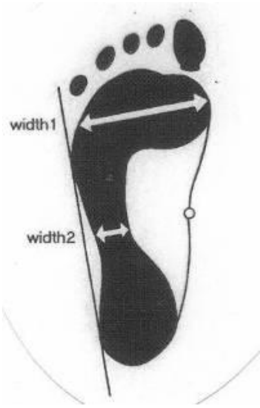

Figure 1. Flat foot

Table 1. Flat foot

$I = w_2 / w_1$	
normal foot	I = less 0, 45
start to be flat	I= 0, 45
flat foot	I= more 0, 45

A questionnaire was distributed to the parents of students after two weeks. Parents were asked to answer four questions concerning the measuring of flat feet. The questions, the percentage of positive answers and the number of questionnaires received back is in Table 2.

Table 2. Flat foot - research results

	Questions for parents	Percentage of answer: YES (2006):	Percentage of answer: YES (2009):	Number of received questionnaires (2006/2009):
1	Do you know a simple method of measuring flat feet?	68	65	75/80
2	Did you receive this method from your children?	60	62	75/80
3	Have you measured your foot using this method?	24	30	75/80
4	Have you found latent flat feet in your family?	4	5	75/80

The research results verify the effectiveness of FS&TE in the primary school science by the use of the combination of hands-on activities and human body measurement.

2.2 Obesity

Our next research concerning the effectiveness of FS&TE was based on the measuring of obesity and it was realized in 2008. One hundred students of the eighth grade in lower secondary science lessons were involved. They were taught how to measure obesity.
Students' knowledge background:

Body weight is defined as an essential parameter that helps us to find out the state of health and even predict health complications in the future. The often used parameter for body weight assessing is body mass index (BMI). The latest investigations verify the importance of the distribution of fat (types of obesity). Fat distribution is possible to find by means of waist and hip circumference which is more predictive of cardio respiratory risks than BMI. The WHR index is the ratio of these two parameters. Only indication of waist circumference is an approximate indicator of the health risks associated with obesity.

Students' hands-on activity:
Use a measuring-tape to measure your waist circumference and hip circumference. Calculate WHR = waist circumference/hip circumference. Evaluate results using the Table 3 and Table 4.

Table 3. Obesity - waist circumference

	Low risk	High risk
Man - waist circumference	> 94 cm	> 102 cm
Woman - waist circumference	> 80 cm	> 88 cm

Table 4. Obesity - WHR

WHR = waist circumference / hip circumference	Types of fat distribution / health risk	boy / man	girl / woman
	Rather peripheral / no risk	up to 0,85	up to 0,75
	Balanced / no risk	0,85 – 0,90	0,75 – 0,80
	Rather central / low risk	0,90 – 0,95	0,80 – 0,85
	Central / high risk	above 0,95	above 0,85

A questionnaire was distributed to their parents after two weeks. Parents were asked to answer questions concerning the obesity measuring. The questions, the percentage of positive answers and the number of questionnaires received back are in Table 5 and Table 6:

Table 5. Obesity (waist circumference) - research results

	Questions for parents	Percentage of answer: YES (2008):	Number of received questionnaires (2008):
1	Do you know a simple method of measuring risk of obesity using indication of waist circumference?	60	84
2	Did you receive a method of measuring risk of obesity using indication of waist circumference from your children?	43	84
3	Have you measured your risk of obesity using this method?	71	84
4	Have you found latent risk of obesity in your family?	22	84

Table 6. Obesity (WHR) - research results

	Questions for parents	Percentage of answer: YES (2008):	Number of received questionnaires (2008):
1	Do you know a simple method of measuring obesity using WHR?	50	84
2	Did you receive a method of measuring obesity using WHR from your children?	43	84
3	Have you measured your WHR using this method?	22	84
4	Have you found latent obesity in your family?	12	84

The results of our second research verify the effectiveness of FSE also in the lower secondary science by the use of a combination of hands-on activities and human body measuring.

3. CONCLUSIONS AND DISCUSSION

The research results verify the educational and motivational effectiveness of FS&TE in the primary school and lower secondary school S&T by the use of the hands-on activities with the human body measurement. FS&TE might hold also another essential function. It can help in the diagnosis and development of gifted students in S&T. According to today's parental demands, school should provide diagnosis of a student's giftedness and carry out further development (Kanevsky, 1992). Professional orientation and student's progress have a comparable value to desirable development concerning his or her future life.

Within the FS&TE strategy, the student's family is able to find out and/or verify the school's recommendation for their child's area of giftedness. As a part of the whole range of other S&T teachers' professional training techniques, the FS&TE strategy is regarded as inseparable from S&T teachers in-service training. It requires understanding the interaction between students and their family background.

FS&TE has a great potential to become an essential strategy for adult lifelong education as well as a motivational technique for gifted and non-gifted students. The interactions between students and their family background include more factors and they are very sensitive. That is why, it requires more detailled additional research and eventual inclusion into pre-service and notably in-service teacher training.

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USE OF MEASUREMENT AND ASSESSMENT TECHNIQUES IN TURKISH SIXTH GRADE SCIENCE AND TECHNOLOGY TEXTBOOKS AND WORKBOOKS

Tuncay Tunç

Science Education Department,

Faculty of Education, Aksaray University, Aksaray - TURKEY

tctunc@gmail.com

Ramazan Avcu

Mathematics Education Department, Faculty of Education, Aksaray University, Aksaray - TURKEY

avcu28@hotmail.com

ABSTRACT

In this research, it was aimed to determine how frequently the alternative measurement and assessment techniques, emphasized by science and technology curriculum, are used in the textbooks and student workbooks, taught in 2008-2009 session, in science and technology course at 6th grade. Within the scope of the research, it was determined how the traditional and alternative measurement and assessment techniques mentioned in science and technology curriculum are used in the books concerned. Moreover, in order to determine the problems teachers are confronted with while using these techniques and to offer proposals of solution for these matters, opinions of 300 science teachers working in various cities were obtained via e- mail. Also, a number of 50 science teachers working in Ankara and Aksaray were interviewed. This study showed that teachers find using alternative measurement and assessment techniques in textbooks and workbooks positive but they do not feel themselves sufficient concerning alternative measurement and assessment techniques. On the other hand, when the negative views are considered, it was observed that teachers stated negative factors as crowdedness of classes, consumption of paper, photocopy and printed documents and insufficiency of time.

Keywords: *Science and Technology; textbooks; measurement and assessment techniques*

INTRODUCTION

Especially together with the development of science and technology, there have been some changes in Science Education Curriculum. The main objective for these changes were enabling students to think creatively, to inquire about events taking place, to think critically and the most important of all is to teach individuals how to be productive. (Balım, Kesercioğlu, İnel, & Evrekli, 2009). These progresses and inventions in Science Education contribute much to the development of a country and constitute a basis for scientific and technologic improvements (Özmen, 2004). In this context, in many countries, Science Education Curriculum was reviewed and reorganized after the consideration of constructivist approach. Constructivism emphasizes the construction of new knowledge by the learner, as well as a focus on active learner-centered experiences (Young and Maxwell, 2007).

Constructivism theory, influenced by the work of Piaget and Vygotsky (Woo & Reeves, 2007), encourages learners to build their own body of knowledge based on individual experience and to apply this knowledge directly to their environment. In constructivism, the individual is at the center of the social process, with the focus on learning rather than on teaching (Ali, Hodson-Carlton, & Ryan 2004). Constructivist approach is defined as individual's correlation of prior knowledge with the knowledge obtained by the interaction between the events and objects existing in his surrounding and constructing it as new knowledge. Constructivist approach is mainly based on Piaget's mental psychology, Ausubel's receptive learning, Bruner's inquiry, Posner and his friends' conceptual change and Johnson and Johnson's social interaction theories(Hand, Treagust, and Vance, K. 1997). Constructivism espouses students are to: be active in the learning environment; develop social and interpersonal skills; enjoy learning; have an understanding of the content being taught; and learn to think in an efficient manner (Kelsey, 2007; Low, 2007).

Irzik (2001), Matthews (2002) and Roscoe (2004) stated that constructivism has vital importance in Science Education since it has an innovative and powerful impact in this field. Due to the use of this approach in learning environments, it has led to redefine concepts such as learning, teaching and knowledge (Chen, Burry- Stock, & Rovegno, 2000). Therefore there have also been changes in the use of measurement and assessment techniques. Constructivism emphasizes that it is necessary to offer multiple assessment opportunities to students, where they can display their knowledge, skills and attitudes, in measurement and assessment as well.

Traditional forms of assessment techniques such as multiple choice tests, true-false questions, matching questions, completion questions, short- answer or long answer examinations and question- answer are easy to administer and grade, whereas they focus on factual recall, promote only simple application of knowledge; and some of them have been found to be teacher-biased (Magnan-Lev, 1997). On the other hand, alternative techniques such as student product file (portfolio), concept maps, constructed grid, diagnostic tree, word association, drama, interview, written reports, demonstration, poster, group and/or peer assessment, self-assessment, diary and checklist are student oriented, they promote learning, involvement and motivation and they also allow for consideration of human characteristics such as prior knowledge, culture and language (Porter, 1991).

According to Pierce and O'Malley (1992) alternative assessment reveals students' knowledge and capability in various contexts; it is authentic because it is based on real life situations. It keeps the interaction between students and teachers alive during teaching and learning processes (Enger &Yager, 1998; Howe & Jones, 1998; Ornstein & Thomas, 2004; Thompson, 2001).

Alternative assessment brings to light not only cognitive but also affective and psychomotor abilities of students. Besides evaluating learning products, it is also effective when assessing the process.(Yaman, Karamustafaoğlu, & Karamustafaoğlu, 2005).

Many educators, who want to emphasize the importance of alternative assessment, made serious criticisms about the handicaps of traditionally used paper and pencil tests (Brooks & Brooks, 1993; Howe et al., 1998; Reeves & Okey, 1996; Smith, Ryan, & Kuhs, 1993; Tippins & Dana, 1992).

Constructivism and in parallel with this alternative measurement and assessment techniques have been a prominent research area for the last two decades (Aldridge, Fraser, Taylor, & Chen, 2000; Avci, Unlu, & Yağbasan, 2009; Demircioğlu, Özmen, & Demircioğlu, 2004; Irzik, 2001; Matthews, 2002; Özerbaş, 2007; Nesbit & Adesope, 2006; Roscoe, 2004; Saygın, Atılboz & Salman, 2006; Semerci, 2001; Aydoğdu, 2003; Taylor & Hsueh, 2005; Rust, O'Donovan & Price, 2005; Thome´ , Hovenberg, & Edgren, 2006).

The new primary education curriculum has been prepared in line with the constructive approach by the Republic of Turkey Ministry of National Education in 2004 and was put into practice in every elementary school of Turkey in 2005-2006 session.

Within the scope of 2004 curriculum reform by Board of Education, the curriculum of the elementary school science course was reevaluated on the basis of constructivism and has been implemented since 2005-2006 session, in Turkey. The name of this course has been changed as “Science and Technology” given the increasing emphasis on the aspects of science topics reflected in the daily life and technology and the class hours were determined as 4 hours per week. Also, textbooks, student workbooks and teacher guide books for this course have been developed in line with the philosophy of this curriculum by General Directors of Primary Education.

The change in the name of the course shows that the science class does not compose solely of knowledge and underline the chief role of technology education in the new curriculum. Furthermore, this change enabled the integration of the technology education and the science topics as a part of the elementary school education for the first time.

The perspective of Turkish Science and Technology Curriculum in terms of assessment and the points it stresses are shown in Table 1.

Table 1. Points stressed by Turkish Science and Technology Curriculum in terms of assessment

Less Stressed	More Stressed
Traditional measurement and assessment methods	Alternative measurement and assessment methods
Assessment independent of teaching and learning	Assessment which is a part of teaching and learning
Assessment of knowledge learned easily and by heart	Assessment of significant and deeply-learned knowledge
Assessment of fragmented knowledge independent of each other	Assessment of a connected and well-constructed knowledge network
Assessment of scientific knowledge	Assessment of scientific understanding and scientific logic
Assessment for learning what the student does not know	Assessment with the purpose of learning what the student has understood
Term-end assessment activities	Assessment activities carried on throughout the term
Assessment only by the teacher	A group assessment with the teacher and self-assessment

When Table 1 is examined, a shift in learning and teaching strategies from teacher - centered structure to student-centered domain can be seen explicitly. This shows that new Turkish science and technology curricula stresses alternative measurement and assessment rather than traditional measurement and assessment (MEB, 2005).

In this research, it was aimed to determine how the traditional and alternative measurement and assessment techniques are used in the textbooks and student workbooks for science and technology course at 6th grade. Moreover, the problems which teachers were confronted with while using these techniques were determined.

METHOD

In Turkey, there are several textbooks published for each grade level of a school subject. School textbooks are designed either by Ministry of Education or private publishers for elementary and secondary school education; however, these textbooks are examined in detail by the Board of Education. Books which are not approved by the Board of Education can not be used as a textbook for teaching at schools. Every year, textbooks are handed out freely to elementary and secondary school students by Ministry of Education.

There are 3 different 6th grade science and technology textbooks and workbooks available on the Turkey market for 2009/2010. As it was our purpose to analyze textbooks and workbooks still in use, publishers were contacted and asked about new books/editions for 2009/2010. It was found that 3 different textbooks and workbooks were either updated or explicitly said to be maintained without any change.

At the first part of the study, a qualitative content analysis of the 6th grade science and technology textbooks and student workbooks by The Ministry of Turkish National Education, Pasifik, Tuna publications, published in 2009-2010 were undertaken. In order to enhance the reliability and validity of the data, the analysis was repeated.

At the second part of the study, it was aimed to determine teachers' views about the sufficiency of alternative measurement and assessment techniques used in 6th grade science and technology textbooks and workbooks.

The population of the study consisted of all the science and technology teachers working in Turkey. The questionnaire was sent to 420 science and technology teachers working in in Ankara, Aksaray, Erzurum, Diyarbakır, Yalova and İstanbul provinces via e-mail. However, 310 of them gave a feed back to us and 10 of them were not evaluated due to insufficient information. As a result the sample of the study included 300 science and technology teachers. A questionnaire and a semi constructed interview were used in the research. The questionnaire was administered to 300 teachers via e-mail and in addition to this, semi constructed interviews were made with 50 teachers giving 6th grade science and technology lessons in rural and urban areas of Ankara and Aksaray.

A questionnaire developed by the researchers was used in order to determine the views of science and technology teachers about the sufficiency of alternative measurement and assessment techniques used in textbooks and workbooks. The legibility and validity of the questionnaire was examined by 3 specialists in the field. The questionnaire comprised of two sections. At the first section of the questionnaire, teachers' profiles and their participation status to in-service training about alternative measurement and assessment techniques and at the second section, teachers' views about alternative measurement and assessment techniques used in the textbooks and workbooks existed.

In order to obtain data about the problems teachers confronted while they were using alternative measurement and assessment techniques, semi constructed interview questions were prepared. Specialist views were taken into consideration in order to determine whether they are suitable for the aim of the study or not.

FINDINGS

Within the scope of the study, it was found out how the alternative measurement and assessment techniques stated in science and technology curriculum are used in the books of different publishers, the techniques used in the textbooks and workbooks are shown in the table given below. Engaging questions existing in the context and in the activities are not included in analyses.

Table 2. Measurement and assessment techniques used in textbooks and workbooks

Measurement and Assessment Techniques		A		B		C	
		TB	WB	TB	WB	TB	WB
Alternative Techniques	Concept Map	●	●	●	●	●	●
	Constructed Grid	-	●	-	●	●	●
	Diagnostic Tree	●	●	-	●	●	●
	Word Association	-	●	●	●	-	●
	Drama	●	-	-	●	-	-
	Interview	●	●	●	-	-	-
	Demonstration	●	●	●	●	●	●
	Poster	●	●	●	●	-	●
	Project	-	●	●	●	-	-
	Written research reports	●	●	●	●	-	●
	Portfolio	-	-	●	-	-	-
	Performance Task	●	●	●	-	-	●
	Table of Semantic Analysis	●	●	●	●	●	●
	Know, Want, Learn (KWL)	●	●	-	●	-	-
	Self-assessment	-	●	-	●	-	●
	Group and/or peer assessment	-	●	-	-	-	-
Traditional Techniques	Multiple-Choice	●	●	●	●	●	●
	Matching	●	●	●	●	●	●
	True - False	●	●	●	●	-	●
	Filling in the Blanks	●	●	●	●	●	●
	Open-Ended	●	●	●	●	●	●

In the books under examination, the measurement techniques measuring the process were generally included along with the outcome; however, it was observed that the measurement techniques for grouping, giving feedback and diagnosing, included at the core of the program, were nearly not used.

When Table 2 is analyzed, it shows that alternative techniques are used more frequently in the textbooks and workbooks of Publishers A and B than the textbook published by C. Besides, utilization frequency of alternative techniques was found to be more in workbooks than textbooks. Demonstration, concept map and table of semantic analyses techniques were used in all the textbooks and workbooks published by A, B and C. The diversity of the alternative techniques used by the workbook of Publisher A, was found to be more than the other textbooks and workbooks. Self assessment technique was used in all the workbooks of publishers; however this technique was not used in textbooks. In addition, group and/or peer assessment was only used in the workbook of Publisher A. Drama, interview, project, portfolio, KWL, group and/or peer assessment techniques was used both in textbook and workbook of Publisher C. As for portfolio technique, it was only used in the textbook of Publisher B.

Moreover, while Textbooks A and B include assessment questions at the end of every topic, Textbook C includes these questions only at the end of the unit. In addition, Textbook A and B have research and getting ready sections along with the topic; however, these sections don't exist in Textbook C.

When the teacher's guide books of these three publishers examined, it was found that teachers were informed on how to use and assess alternative techniques by instructions. Moreover, in all the three teacher's guide books self assessment, group and/or peer assessment, project assessment rubrics and student observation form and control form for experiments existed in order to be helpful for the teachers.

Traditional techniques were used sufficiently in all the textbooks and workbooks of publishers.

In addition to the measurement and assessment techniques referred to above, open ended questions that can attract students' interest was used too often in the context of all the textbooks of publishers. Besides, textbooks were also analyzed in order to see whether they may promote a student's active role in the learning process or not. Textbooks should ask students to perform reasoning (minds-on) activities as well as practical (hands-on) activities and this should be done before presenting them with the content to be learned. (Leite,1999).

Table 3 shows the results of the analysis concerning both the existence of learning activities (minds-on and hands-on) and the location of the content with reference to the activities included.

Table 3. Requirement of students' activity

Categories of analysis	A		B		C	
	TB	WB	TB	WB	TB	WB
Minds-on activities	12	155	3	170	-	173
Hands- on activities	67	16	52	7	62	9
Total	79	171	55	177	62	182
Content is given:						
-before the activities	•	There is no content in workbook	•	There is no content in workbook		There is no content in workbook
-after the activities						
-sometimes after; sometimes before					•	

The analysis of the data given in Table 3 leads to the conclusion that all textbooks include some activities to be carried out by the students. Textbook C is the only one that does not include minds-on activities to be performed by its users. Hands-on activities are frequently used by all textbooks; in addition, minds-on activities are preferred more often in all the workbooks. Textbooks A and B always present the content needed before introducing the activities, whereas textbook B present the content sometimes after and sometimes before introducing the activities.

New Science and Technology Curriculum aims to educate all students in being science and technology literates whatever their individual differences are. The curriculum not only aims to convey today's knowledge to the students but also it aims students to be inquiry, to make connections between daily life and science topics, to be able to use scientific methods when confronted with daily problems and to be able to evaluate events in the view of a scientist. With this purpose the curriculum advices textbook authors to use "minds-on activities" and "hands-on activities very often (MEB, 2005).

FINDINGS OBTAINED FROM QUESTIONNAIRES

The teachers' profiles and their participation status to in-service training about alternative measurement and assessment techniques are shown in Table 4.

Table 4. The teachers' profiles and their participation status to in-service training about alternative measurement and assessment techniques

Characteristic	Categories	f	%	Characteristic	Categories	f	%
Gender	Male	168	56	Participation status to in-service training about alternative measurement and assessment techniques	Yes	230	76.7
	Female	132	44		No	70	23.3

Data given in this table shows that 56% of the teachers participated in the questionnaire were male and 44% were female. Also 76.7% of the teachers attended in-service training about alternative measurement and assessment techniques.

The common views found out with respect to the measurement and assessment aspects of textbooks and workbooks at the end of the questionnaire review made within the scope of the study are stated in the following Table 5.

When the views of science teachers about measurement and assessment techniques used in textbooks and student workbooks are examined, it is observed that teachers found the books generally sufficient for most criteria. Nevertheless, it is an engrossing finding that the rate of teachers thinking that the books concerned require to be developed in terms of measurement instruments' level of measuring critical gains exceeds 50%. Hence, this should be taken into account in the student workbooks to be rewritten or revised.

Teachers' positive and negative views about alternative measurement and assessment techniques used in textbooks and workbooks are presented in Table 6 based upon interview data.

Table 5. Views of science teachers about measurement and assessment aspects of the textbooks (TB) and workbooks (WB) of science and technology course

Assessment Criteria for Science and Technology Books		Sufficient		Should be Developed		Total	
		TB	WB	TB	WB	TB	WB
Level at which the given measurement instruments reveal gains	f	182	178	118	122	300	300
	%	60.7	59.3	39.3	40.7	100.0	100.0
Suitability of the used measurement instruments for the subject	f	187	191	113	109	300	300
	%	62.3	63.7	37.7	36.3	100.0	100.0
Suitability of measurement instruments for the level of the student	f	174	179	126	121	300	300
	%	58.0	59.7	42	40.3	100.0	100.0
Level at which measurement instruments measure critical gains	f	141	148	159	152	300	300
	%	47.0	49.3	53.0	50.6	100.0	100.0
Serviceability of measurement instruments	f	154	161	146	139	300	300
	%	51.3	53.7	48.7	46.3	100.0	100.0
Level at which measurement instruments reveal basic skills	f	193	189	107	111	300	300
	%	64.3	63	35.7	37.0	100.0	100.0
Suitability of assessment for measurement instruments	f	184	188	116	112	300	300
	%	61.3	62.7	38.7	37.3	100.0	100.0
Suitability of the measurement instruments given at the beginning of unit/theme/learning domain	f	180	183	120	117	300	300
	%	60.0	61.0	40.0	39.0	100.0	100.0
Suitability of the measurement instruments given within the process of learning in units and themes	f	168	174	132	126	300	300
	%	56.0	58.0	44.0	42.0	100.0	100.0
Suitability of the measurement instruments given within the process of learning in units and themes	f	168	174	132	126	300	300
	%	56.0	58.0	44.0	42.0	100.0	100.0
Suitability of the measurement instruments given at the end of unit/theme/learning domain	f	152	156	148	144	300	300
		50.7	52.0	49.3	48.0	100.0	100.0

Table 6. Teacher's views about the measurement and assessment techniques used in textbooks and student workbooks

Positive aspects	Negative aspects
• All types of questions were used and individual differences were taken into consideration. • Measurement and assessment materials attract attention of students more • It gives students opportunities to self assess and fulfill their needs. • It helps teachers to reform themselves. • Measurement and assessment is not fearful, it is informative and enhancive. • Diversity of assessment identifies the student and makes it easy to assess. • Not only product but also process is assessed. • Measurement and assessment materials also help to improve teachers. • Measurement and assessment materials used in textbooks and workbooks are sufficient and they reinforce learning. • Questions based on estimation and discussion in the context helps to measure and assess. • Measurement and assessment activities are appropriate for the levels of students and they identify what they learnt. • They give students opportunities to self assess and they are convenient for multiple intelligence.	• Assessment forms are excessive and very difficult to implement them all. • The consumption of paper and printed documents and the cost of photocopying increase. • Due to crowdedness of classrooms, assessments are made without considering the goal properly and completely. • Lack of materials affects assessment negatively. • When self assessment forms are filled in by the students, they are not objective enough • It is impossible to prepare, and keep all the forms. • Measurement and assessment takes too much time and stationery costs a lot. • Some concept maps are complex. • Alternative measurement and assessment techniques are not sufficiently known and in-service trainings are inadequate. • Assessment takes a very long time in crowded classes. • It is difficult to check and assess projects and performance tasks.

When Table 6 is examined, it is understood that teachers find the measurement and assessment techniques used in textbooks and workbooks positive but they do not feel themselves sufficient concerning alternative measurement and assessment techniques. On the other hand, it was observed that teachers stated negative factors as crowdedness of classes, consumption of paper, photocopy and printed documents and insufficiency of time.

DISCUSSION AND CONCLUSION

Alternative measurement and assessment techniques are essential subjects, upon which most curricula in the developed countries of the world. In elementary school curricula that are put into practice in Turkey in 2005-2006 educational year, teachers were asked to use alternative measurement and assessment tecniques besides using traditional ones.

As a result of analyzing alternative measurement and assessment techniques used in the books, it was seen that while there are some points completely in accordance with the principles of constructivism, there are also some insufficient and inadequate points. For instance; in the textbooks, measurement and assessment materials used in textbooks and workbooks can help students both to internalize information easily and to integrate information related to tools used in daily. Moreover, it was observed that textbooks and workbooks are adequate to include measurement and assessment materials. However, the workbook activities are considered to have a better design to address to the students with different intelligences (Gardner & Hatch, 1989), in comparison with the activities in the textbook. Furthermore, it was found that the workbook is especially better in terms of using alternative measurement-assessment techniques and methods.

Additionally, some sufficient and insufficient points in the textbook and workbook are revealed as a result of analyzing teachers' views about the sufficiency of alternative measurement and assessment techniques used in the books.

One of the most frequent positive views about measurement and assessment concerns the renewal of the curriculum that evaluates both the result and the process. Another one is that the books include activities checking the pre-knowledge. Moreover, performance tasks and projects are considered positive by the teachers. Student self-assessment and group / peer assessment are further positive aspect of the books. The most common negative view on measurement and assessment is that the scoring criteria are not explanatory, graded scoring key is not user friendly and the number of assessment forms is excessive. The reason why the teachers assess in this fashion might be that they think all the forms should be frequently used. Moreover, the teachers might have neglected that the forms are not necessarily used for all the students at the same time. Another negative aspect in terms of measurement and assessment is that the students face difficulties in assessing themselves and their group members. Finally, the troubles in the use of concept maps increase in paper consumption, preparation of Secondary School Entrance Exams according to the old elementary education curricula are among the most frequently encountered negative views. In order to overcome this problem, a secondary education pass system, based on the renewed elementary education curricula, was put into effect in 2007-2008 session for admitting the students to secondary education. Therefore, it is aimed to apply the education curricula successfully and to increase the use of textbooks that are one of the basic tools of this application.

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MORAL REASONING PATTERNS OF PRE-SERVICE SCIENCE TEACHERS TOWARD LOCAL AND NON-LOCAL ENVIRONMENTAL PROBLEMS

Busra Tuncay	Ozgul Yilmaz-Tuzun	Gaye Teksoz
Giresun University	METU	METU
tbusra@metu.edu.tr	ozgul@metu.edu.tr	gtuncer@metu.edu.tr

ABSTRACT

In the study, the assumption that there may be differences in moral reasoning patterns (i.e. ecocentric, anthropocentric, non-environmental) of people toward local and non-local environmental problems was tested. In the first two administration periods, one hundred and twenty pre-service science teachers listed their concerns regarding four non-local and four local environmental problems. Then, interviews were conducted with 16 of the participants (8 male and 8 female), four from each grade level, who were randomly selected among the volunteers. Content analyses were carried out on participants' written responses to the given local and non-local environmental problems, and qualitative data analysis was implemented to interpret the interviews and examine participants' environmental moral reasoning deeply. Analyses revealed that participants of the study were more concerned about the effects of the environmental problems on environment itself when the problems were non-local, whereas their anthropocentric concerns were higher for local environmental problems than non-local ones. Found differences indicate the importance of situational factors for environmental moral reasoning and point out the necessity of improvement in coverage of local environmental issues as well as non-local ones in various aspects.

Keywords: *Moral reasoning, local environmental problems, non-local environmental problems, teacher education.*

INTRODUCTION

Many years ago, it was stated that the main reason of the environmental crisis, which we still try to cope with today, was human behavior and the best way to solve many environmental problems was described as educating people and creating changes in their behaviors so that they become more environmentally friendly (Maloney & Ward, 1973). At this point, Gurevitz (2000) argued that affective forms of environmental education encourage individuals to engage in pro-environmental behaviors more when compared to approaches aiming to increase amount of scientific knowledge about environmental issues in their learners. Similarly, many studies and important reports on environment reveal the importance of affective approaches, especially integrating environmental ethics in environmental education. For instance, in Tbilisi declaration (1978) it was indicated that environmental education should educate individuals in a way that they can understand the problems of our world and protect environment with regard to ethical values.

In addition, owing to the comprehensive characteristics of environmental problems, which have political, economical, and social aspects (Chan, 1999), it can be stated that environmental knowledge should also include moral decisions about values and powers (Hausbeck, Milbrath, & Enright, 1992) as well as basic scientific knowledge. Furthermore, research show that in addition to these various aspects of environmental problems, there are additional factors that are affective in people's perceptions related to environmental problems such as the risks people attach to the issues (Bamberg, 2003).

Correspondingly, researchers of the present study hypothesized that there may be some differences in moral reasoning patterns of people toward local and non-local environmental problems due to the possible differences in the risks attached to them. In fact, findings of some research strengthen this assumption. For instance, in their study, Duan and Fortner (2005) concluded that there were some differences in Chinese college students' perceived risks of global and local environmental issues, such as significance and danger as well as certainty, complexity, and tangibility.

In accordance with the aim of the study, pre-service science teachers' moral considerations related to four local and four non-local environmental cases about deforestation, e-waste, oil spill, and global warming environmental problems were examined. The cases that exist in the country where the study took place were defined as local, and the other ones as non-local.

Where 'moral reasoning' is defined as a thinking process with the objective of determining whether an idea is right or wrong (Littledyke, 2004), the researchers of the present study described 'environmental moral reasoning' as the thinking process of determining whether an idea/action is right or wrong with regard to environmental improvement and protection. Since people have different motives, or reasons, for valuing nature (Bjerke & Kalternborn, 1999), they may develop different reasoning patterns toward environmental problems. Likewise, as have been stated previously, the researchers of the study aimed to examine whether these motives or reasons that the participant pre-service science teachers possess were different for local and non-local environmental problems or not.

Similar to Kortenkamp and Moore (2001), three categories were used for labeling moral reasoning patterns of the participants: ecocentric (valuing nature due to its intrinsic value), anthropocentric (belief in the importance of environmental quality due to its usefulness to humans), non-environmental (concentrating on other aspects of the environmental problems such as laws).

Consequently, the present study is believed to have important contributions to the development of effective environmental education programs with its findings and implications by revealing the importance of affective approaches, namely morality, for people's perceptions about environmental problems and their motivation to exhibit pro-environmental behaviors once more. Furthermore, the study has additional significance for the improvement of environmental education owing to its sample being pre-service science teachers. In the view of the fact that pre-service science teachers will be role models for their own students in future and have active roles in achieving ultimate goal of environmental education, which is educating environmentally responsible citizens (Culen, 2001), determining their moral approaches toward environmental problems and giving feedback to educators at education faculties of universities is important.

Finally, the findings of the study will reveal some implications about the relationship between culture and environmental moral reasoning, and contribute to the related literature significantly because it is seen that although number research conducted on this subject is increasing in an encouraging manner it is not satisfactory, especially in non-western countries. Therefore, examining moral reasoning patterns of pre-service science teachers and investigating possible factors that may influence these patterns in the context of a non-western country seems to be consequential.

METHOD

SAMPLE

The participants of the study were 120 pre-service science teachers with a mean age of 22.08 years (N_{male}=31, N_{female}=89). They were first, second, third, and fourth grade university students who enrolled in elementary science education department of a large research oriented university and constituted 60% of the accessible population (N_{male}=62, N_{female}=138). In addition, among the volunteer participants, 16 of them (N_{male}=8, N_{female}=8) were selected in equal numbers from each grade level and interviews were conducted to follow up and refine the quantitative findings of the study.

INSTRUMENTS

For the study, four local and four non-local environmental cases about deforestation, e - waste, oil spill, and global warming environmental problems were prepared by the researchers. Based on the importance of using real life problems for the effectiveness of environmental education (Tuncer & Erdoğan, 2006), the researchers of the study preferred to use real environmental cases rather than hypothetical dilemmas for examining moral reasoning patterns of pre-service teachers toward the presented environmental problems. In the same way, information given in the texts related to the cases were reached from sound resources including articles presented in various databases, important reports related to environment, and declarations of Ministry of Environment and Forestry of the country. After the cases were prepared by the researchers and an agreement was established between them, the final structures of the cases were presented to an expert committee. The experts in the committee were asked to examine the cases in terms of the sufficiency of the given information as well as equivalence of the amount and type of the enhanced information such as problems' effects on humans and on environment itself.

As a second instrument, Moral Decision-Making Interview (MDMI) protocol developed by Sadler and Zeidler (2005) was used with some adaptations that aimed to help interviewees focus on the eight environmental cases regarding the four environmental problems. The aim of the interviews was to examine moral reasoning of the participants in a deeper manner and reveal the possible factors that influenced their moral reasoning patterns toward local and non-local environmental problems. Language of the cases and the interview protocol were in English. This situation does not seem to be a limitation for the study because since the education language of the university where the study took place is in English, participants had the necessary competencies in comprehending and responding to the data collection instruments. Even so, interviewees responded to the questions asked during the interviews in their native language so that they were more relaxed and reflected their opinions and feelings more comfortably.

DATA COLLECTION AND ANALYSES

Data collection period of the study took two semesters (2008-2009 Fall, 2008-2009 Spring) to be completed and was carried out in two administration periods apart from the interviews. In the first administration period, participants' responses to non-local environmental cases were collected, and after two months, local environmental cases were administered. For each administration, the participants were asked to list and explain their considerations that concerned them most about each environmental case. With the two month of the time interval between administration of non-local and local environmental cases, possible interaction between participants' responses to the cases was aimed to be eliminated. After the administration of the cases, e-mails of the participants who were willing to participate in the follow up interviews were collected and meeting hours were arranged with 16 of the volunteers. Based on findings of some research that resulted in different moral reasoning patterns in males and females (e.g., Ford & Lovery, 1986), equal number of males and females were invited to the moral reasoning interviews: two males and two females from each grade level. The interviews were semi-structured and lasted about 30-45 minutes.

Content analysis was carried out on the written statements of participants reflecting their concerns about the distributed environmental cases and each statement was coded as ecocentric, anthropocentric or non-environmental according to their meanings, which were explained in the introduction part of the paper. An inter-rater agreement of 95% was achieved after the coding process of the responses by the researchers. Then, the calculated frequencies of each moral consideration category were entered to the Statistical Package for Social Sciences (SPSS) version 15.0 for Windows for descriptive and inferential analyses.

In addition, Miles and Huberman's (1994) approach of qualitative data analysis was utilized for the analyses of the interviews, which were audio-taped and transcribed by the researchers in order to make sense of the obtained data. Throughout the analyses, the second and third authors of the research reviewed 20% of the interviews and the agreement in the coding of the statements was found to be 87%. The remaining analyses were performed by the first author according to the agreed coding.

RESULTS

Content analysis of the participants' responses regarding their concerns about the presented environmental cases demonstrated that they generally tended to concern more about the problems' effects on environment itself rather than the harms people had to face due to these problems or problems' other aspects such as being against laws or rules of the society. Distribution of ecocentric (eco.), anthropocentric (anthro.) and non-environmental (NE) moral considerations as well as total number of concerns (total) stated for local (local) and non-local (Non-local) environmental cases, and for the environmental cases when they were taken as a whole (TOTAL), regardless of their being locality are demonstrated in Figure 1. Corresponding values represent the mean values of the calculated frequencies for each moral consideration category.

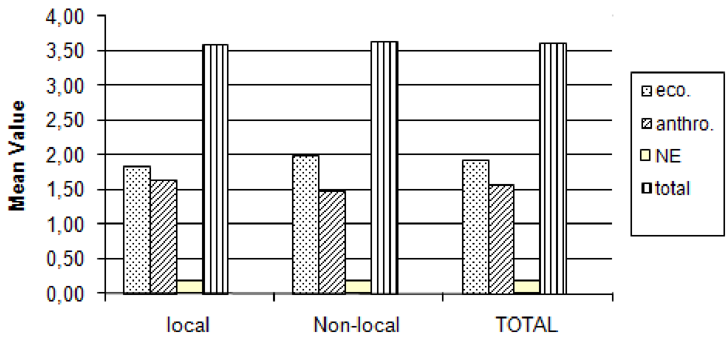

Figure 1. **Mean values for ecocentric (eco), anthropocentric (anthro.), non-environmental (NE), and total (total) moral considerations.**

As have been stated previously, the values show that pre-service science teachers who participated in the study exhibited mostly ecocentric moral concerns, then anthropocentric concerns and finally non-environmental concerns for both local and non-local environmental problems. Nevertheless, oil spill case among the non-local environmental cases and global warming case among the local cases received higher anthropocentric concerns than ecocentric concerns by the participants. Mean values calculated for ecocentric (eco.), anthropocentric (anthro.) and non-environmental (NE) moral considerations as well as total number of concerns (total) stated for each environmental case are tabulated in Table 1.

Table1. ***Mean Number of Moral Considerations for Non-local and Local Environmental Problems***

		Deforestation	E-waste	Oil spill	Global Warming	Average
Non-local	Eco.	1,92	2,10	1,73	2,25	2,00
	Anthro.	1,38	1,33	1,77	1,43	1,48
	N.E.	0,32	0,21	0,17	0,03	0,18
	total	3,58	3,56	3,65	3,68	3,63
Local	Eco.	2,16	1,94	1,75	1,45	1,83
	Anthro.	1,51	1,19	1,73	2,07	1,63
	N.E.	0,07	0,50	0,15	0,01	0,19
	total	3,68	3,50	3,61	3,54	3,59

Furthermore, analyses revealed that global warming problem among the non-local environmental problems and deforestation problem among the local environmental problems received more concerns by the participants. In addition, comparison of the mean number of moral considerations for local and non-local environmental problems resulted in some remarkable findings. It was found that participants' ecocentric concerns were higher for non-local environmental problems than for local ones. Similarly, their total concerns toward the presented non-local environmental problems were higher than for local environmental problems. Conversely, they demonstrated more anthropocentric concerns toward local environmental problems than they did for non-local environmental problems, which means they paid more attention to the effects of environmental problems on humans when the problems were in their own country.

Further inferential analyses, namely dependent samples t-tests, conducted to test the significance of the differences between moral reasoning patterns of the pre-service teachers toward local and non-local environmental problems demonstrated that there was a statistically significant difference in ecocentric moral considerations ($p = .043$) of the participant pre-service science teachers. On the contrary, differences in their anthropocentric ($p = .109$) and non-environmental ($p = .946$) moral considerations as well as total environmental concerns ($p = .453$) were not statistically significant.

Finally, follow up interviews conducted to investigate moral reasoning of the participated pre-service teachers deeply and examine factors that influence their moral reasoning patterns also supported the results mentioned above. They were more concerned about the effects of the environmental problems' effects on environment itself when the problems were non-local, whereas they exhibited more anthropocentric concerns toward the local environmental problems. Statements of one of the participants clearly supports this argument: " I know… maybe I should be equal distance to the two situations [means local and non-local] but I care my own county's people more than animals, or plants in this country. I mean… they are our people. However, when it comes to another country… my logic comes before my emotions. Plants and animals are more important for ecological balance."

In addition, some possible reasons for this difference arose from the interviews. Some participants implied media for the difference in their concerns toward local and non-local environmental problems, as demonstrated by the following quote: "…In news while showing these kinds of things [means news on environmental issues] in the world, they mostly show animals who are suffering. For instance, when I think about melting of glaciers there is a picture in my mind: a lonely polar bear on an ice cap looking its surrounding… so, people become unimportant. However, for example, when there is a water shortage, the most important thing seems to be people. In news, you see farmers who are in bad conditions for example and since you, yourself, cannot find water, you do not care animals, or plants."

DISCUSSION

Findings of the analyses conducted to examine environmental moral reasoning of pre-service science teachers who participated in the study showed that they were more concerned about the effects of environmental problems on environment itself, rather than their effects on humans or the non-environmental aspects of these issues such as being illegal. This finding differs from some previous research conducted in other countries implying possible effect of culture on moral reasoning patterns. For instance, contrary to the participants of the present study, undergraduate students who participated in the study of Kortenkamp and Moore (2001) exhibited non-environmental moral reasoning with the highest frequency. Moreover, mean number of their anthropocentric reasoning were found to be higher than mean number of their ecocentric reasoning.

In addition, as have been hypothesized at the beginning of the study, differences were found in the mean number of ecocentric, anthropocentric, and non-environmental concerns of the participants toward local and non-local environmental problems. This finding is supporting Kortenkamp and Moore's (2001) study by revealing the importance of situational variables, such as locality of environmental problems, for environmental moral reasoning patterns once more.

In their study, Kortenkamp and Moore (2001) showed that information enhancement about the effects of environmental issues on environment and on humans affected their participants' moral reasoning categories. Their participants demonstrated more ecocentric concerns when information about the effects of the environmentally damaging actions on environment was enhanced in the distributed dilemmas. Correspondingly, as Chan (1999) stated, wide media coverage of environmental issues such as global warming and depletion of ozone layer focus people's attention to these environmental issues and when people perceive environmental issues more significant and dangerous, they become more concerned (Duan & Fortner, 2005). These research explain the higher ecocentric concern of the participants exhibited toward non-local environmental problems presented in throughout present study. Since non-local environmental problems, such as water scarcity due to global warming, and deforestation of Amazon rain forests take more place in media and their environmental significance are presented more, study's participants may have stated more ecocentric concerns to the non-local issues than local ones presented in the study. On the other hand, as also seen in the follow-up interviews, local environmental problems take more place in media with their impacts on humans and the economy of the country since the country is a developing country with many economical problems. Therefore, participants of the study paid more attention to the effects of local environmental problems on humans more and exhibit anthropocentric moral considerations toward these issues more.

To sum up, this study is an indication of the importance of situational factors for people's environmental moral reasoning and the necessity of improvement in coverage of environmental issues on local environmental issues as well as non-local ones in various aspects. Since, different people may have different motives, or reasons, for valuing nature (Bjerke & Kalternborn, 1999), if we educate our teacher candidates who are aware of all of the aspects of environmental issues such as social, economical, environmental, and legal, they will be able to educate their own students accordingly, and thus promote environmentally friendly behaviors in the society.

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ASSESSING PRESERVICE SCIENCE TEACHERS' NATURE OF SCIENCE UNDERSTANDINGS: FROM EXPLICIT TO TACIT

Halil Turgut

Marmara University

halil.turgut@marmara.edu.tr

ABSTRACT

The importance of accurately teaching NOS to individuals is widely recognized and the issue of exposing and assessing the NOS understandings, especially the tacit ones, seem to be crucial. The purpose of this study, therefore, was to explore both the explicit and more deeply-held tacit NOS understandings with an interpretative research design. Thirty preservice science teachers were enrolled in a STS course in the context of demarcation of science from pseudoscience. Open ended questions and activity sheets prepared by participants constituted the data sources which were analyzed qualitatively. The results of the research implied that participants' explicit NOS understandings were naive for various aspects with an absolutist view of scientific knowledge in a belief-free context that can be gained through a universal, unique scientific method involving a set of fixed stages. The tacit understandings were seen to be in accordance with these explicit ones and portray a general view of science based on "discovery" of "facts" without any interpretation. Solely, direct observations or experiences of "facts" without any inferences were seen to be viewed as doing science by participants. Morever, the participants' tacit understandings seemed to form the basic rationale for their explicit views which should be examined further.

Keywords: *NOS Understandings, Explicit, Tacit*

INTRODUCTION

The importance of accurately and deliberately teaching NOS to individuals is widely recognized as evident in science education reform documents (Clough, Olson, 2008; Meichtry, 1993; Kang, Scharmann & Noh, 2005) and the development of individuals' understandings of the NOS has been considered as an important aim of science instruction (Duschl 1990; Meichtry 1993; Kang, Scharmann & Noh 2005). However, little done to provide some instructional methods to enhance the development of the NOS understanding (Scharmann, Smith, James & Jensen 2005) and as a consequence of diverse definitions developed over several decades, researchers had been seen to not share a common conception of NOS (Abd-el Khalick, Bell & Lederman 1998; Kang, Scharmann, Noh 2005). The philosophers, historians and sociologists of science are quick to disagree on specific issues (Lederman, Abd-El-Khalick, Bell & Schwartz 2002) and have proposed different views about what science is and how it works with different rationales. But, most of these disagreements about the NOS are seen to be irrelevant to science education (Abd-El-Khalick, Lederman 2000) and the shared wisdom at a certain level of generality about the NOS among the philosophers of science (Smith, Lederman, Bell, McComas, & Clough, 1997) constituted a common ground for science education.

Based on this common ground, the nature of science (NOS) is often seen to be used to refer to both the epistemology and sociology of science as a way of knowing including the values, beliefs inherent to scientific knowledge (Lederman, 1992), ontological foundations of science (Clough, Olson, 2008) and understandings about the organization of science as an enterprise (Ryder, Leach, & Driver, 1999). Such a perspective underlines some aspects such as; (i) tentativeness, (ii) empirical nature, (iii) theory-laden nature, (iv) socio-cultural embeddedness; (iv) myth of a universal scientific method; (v) roles of hypothesis, theories and laws; (vi) creativity and imagination and, (vii) persuasive communication, for a basic understanding of the NOS (Smith, Scharmann 1999; McComas, Clough & Almazroa 2000; Lederman, Abd-El-Khalick, Bell & Schwartz 2002). So, without ignoring the philosophical debates about specific issues and the related complexity, these aspects mentioned in many documents should be claimed to establish an acceptable ground for the NOS (Lederman, Abd-El-Khalick, Bell & Schwartz 2002), which is crucial for clarifying the intention teaching.

The search of related literature indicated two general positions for such an aim of teaching the NOS which Bravo (2004) called as ‘curriculum perspective’ and ‘meta-theoretical perspective’. According to curriculum perspective, the focus is on the intrinsic value of the NOS for the education of citizens, which based on democratic and cultural arguments. An understanding of the NOS is evaluated as necessary for making sense of socioscientific issues, participating in the decision-making process (Driver, Leach, Millar & Scott 1996; Zeidler, Walker, Ackett & Simmons 2002) and seen to be crucial for effective local and global citizenship (Smith & Scharmann 1999). Being an educated citizen of the twenty-first century is not claimed to require just to know science but also to know about science; how it is created, how it evolves through history and how it relates to society and culture (Bravo, Merce & Anna 2001). On the other hand, in the meta-theoretical perspective NOS is assumed to represent a second order reflection on the content and methods of science that positively contributes to teachers’ autonomy especially when transforming scientists’ science into school science (Bravo 2004).

However the results of previous researches concerned with improving students’ understanding of the NOS indicated that students from various age groups and even teachers possess both inaccurate and inappropriate views of NOS regardless of the instruments or methods used in investigations (Lederman, 1992; Duschl, 1990; Abd-El-Khalick, & Lederman, 2000). Such a failure had explained by the help of the view that perceptions about the NOS are well assimilated into mental structures and resistant to change (Meichtry, 1992). Hence, any expected development in the NOS understandings firstly requires the exposing of the current perceptions to challenge or alter and this issue addresses the effective assessment of NOS understandings which still remains equivocal (Lederman, Wade, & Bell, 1998; Craven, Hand & Prain, 2002). An important aspect in this context is related with the nature of assessment and the underlying assumptions of the instruments used that are either standardized or open ended but an additional one should also be considered; the distinction between explicit and tacit understanding forms.

The search on the assessment of the NOS understandings indicate the use of standardized or open ended questionnaires with a general tendency towards assessing the explicit understandings which individuals can immediately access and verbalize while communicating with others. However, the assessment of tacit understandings which are unarticulated but are demonstrable by use and action (Polanyi, 1966) are seemed to be overlooked. Although has been used in various ways, tacit knowledge is seen to be defined as the procedural knowledge (rather than the factual one) about the things that have personal importance for the learner and assumed to be learnt without the help of others or any explicit instruction (Sternberg et al., 2000; Torff, 1999) and hence, should be held seriously in educational practice as intuitive conceptions. The purpose of this study, therefore, was to expose and assess both the explicit and more deeply-held tacit NOS understandings of the pre-service science teachers in which various aspects were considered for a basic understanding of the NOS.

DESIGN ISSUES

The present study made use of an interpretative research design with a qualitative data analysis approach (Strauss, Corbin, 1998) to examine both the explicit and tacit perceptions of pre-service science teachers about the NOS.

PARTICIPANTS AND CONTEXT

Participants of this research were 30 pre-service science teachers of 13 males and 17 females with ages ranged from 20 to 22 at the undergraduate level in a state university, in Istanbul, Turkey. They were enrolled in the Science-Technology-Society course, taught by the researcher for three hours a week for a period of 12 weeks. All the participants had completed science courses of the teacher education program such as physics, biology and chemistry but none of them had any prior instruction related with the nature, history and philosophy of science. The research covered the first three weeks of the course, the introduction phase, in which the NOS as the core concept under the heading of scientific literacy and the issue of the demarcation of science from pseudoscience as the context of the course were presented to participants. In this phase, any informative instruction about any aspect of NOS did not performed in the class but a common understanding about the context of demarcation of science from pseudoscience was tried to be constructed conceptually. For this, the case of being pseudoscientific was introduced to participants; it defined as having the claim of being scientific although do not meet various standards mentioned by philosophers of science (Preece & Baxter, 2000), and some samples, especially the ones which placed in the popular media such as astrology were briefly overviewed in the class. Within this process, the participants did not have any instruction about the criteria proposed by various philosophers of science and the arguments about the issue of demarcation but tried to be informed about the term pseudoscience to establish a common ground for the context. At the end of this process, the participants were asked to design an activity which should be performed in the elementary science classes, to provide students a basic understanding about the main properties of scientific enterprise and the criteria for demarcating it from pseudoscience.

DATA SOURCES AND ANALYSIS

Two data sources were used in this research to expose and assess the participants' both explicit and tacit understandings about the NOS. The first data source was the "*Views of Nature of Science Questionnaire-C* (VNOS–C)" that developed by Lederman et al. (2002), that based on various aspects of NOS such as the empirical nature of scientific knowledge, the theory-laden nature of observations, the socio-cultural embeddedness of scientific knowledge, scientific method/methods and the scientific theories, laws. The intention of this questionnaire was to examine the explicitly pronounced NOS understandings of the participants and was given to them at the first week of the course. So, these explicit understandings were thought as the experience based beliefs of the participants about the NOS, which were developed within their formal education up to this course. The second data source was the set of activity sheets prepared by the participants to emphasize the criteria for demarcating science from pseudoscience, after the introduction of the concept of pseudoscience in the course. With the analysis of these activity sheets, the determination of the tacit understandings of the participants about the NOS was aimed. These activity sheets were examined to elicit the participants' tacit understandings about science as an enterprise, which did not pronounced explicitly but reflected in the process of demarcating it from pseudoscience, in action.

Both data sources were analyzed comparatively for each participant and the analyses began with the search of patterns in the data to derive a coding system. For this, the responses for the open ended questions and the activity sheets of each participant were read and any bit of information related with the issue stated by a word, a sentence or a whole paragraph was used as a conceptual construct to be coded. The list of codes established was then narrowed and a new list of codes developed to sort the data mechanically (Gay, Mills & Airasian, 2006; Bogden & Biklen, 2007). With the help of this sorting process, various themes were determined and grouped into more abstract constructs; categories (Strauss, Corbin, 1998; Maxwell, 2005; Creswell, 2005). Then, the data sources were again examined to evaluate the success of these themes for representing the existing data. This process also provided the researcher to determine the frequencies of the emergence of these themes across the data sources. When it was satisfied that the themes represented the data adequately, the analyses process ended and the distribution of the participants for these themes were clarified.

RESULTS AND DISCUSSION

The results of the research presented in this section were grouped under two headings according to the understanding forms that examined about the NOS; (i) participants' explicit NOS understandings and (ii) participants' tacit NOS understandings.

PARTICIPANTS' EXPLICIT NOS UNDERSTANDINGS

The qualitative analysis of the responses given to VNOS-C questionnaire implied that the majority of the participants held naive views about several NOS aspects. An absolutist view of scientific knowledge in a belief-free context that can be gained through a universal, unique scientific method involving a set of fixed stages was seen to be central in these explicit NOS understandings.

The great portion of the participants (73%) defined science as a fact based discipline demanding certain answers to questions through an exact method which has unique steps to follow with experimentation at the core. With this perspective, the participants presented experiments as a "proving" process and dismissed the possible role of personal and social factors in the generation and validation of scientific knowledge:

> "Scientists seek the answers of questions about nature. They use the scientific method and make experiments about the facts. They prove their results and everyone accept the results without any discussion. Religion is personal, you can believe or not and in philosophy everyone can propose opinions" (P 11).

The difference of science from other disciplines was also seen to be based on this argument by the participants and religious, philosophical fields were labeled as disciplines which rely upon ideas and mere opinions contradictory to the definite conclusions of science that arrived by the use of facts. This idea of "proving" by experimentation and having certain answers at the end of the process was also seemed to be reflected in various aspects of the NOS understandings by the participants. The tentativeness of the scientific knowledge and the status of scientific laws, theories were among these.

A majority of the participants (80%) presented scientific knowledge and, especially scientific laws, as certain constructs which have been proved to be true many times by experiments and accepted by everyone without any doubt. In this context the tentativeness of the scientific knowledge was seen to be denied by this group of participants. Its certainty was claimed to be satisfied at the end of the process in which any socio-cultural factor do not have any role:

> "Scientists perform experiments about the facts they examine and after they perform many experiments they reach certain scientific laws which are valid for everyone at everywhere. They are then proved to be true" (P2).

It should be noted that nearly all the participants used the concept "tentativeness" in their discussions but it was seemed to be emphasized mainly for scientific theories which are not "proved" yet. They defined scientific theories as immature products of science, an intermediate phase in the generation of certain scientific knowledge, and presented the development of technology as the main reason for a possible rebuilding process.

In accordance with these arguments about the tentativeness of the scientific knowledge, theories and laws, a majority of the participants (87%) asserted a hierarchical relationship between scientific theories and laws. They claimed that the scientific theories, which are unproven yet and hence unaccepted by the scientific community, become scientific laws after they are confirmed by many experiments and researches:

> "Scientists have some theories and study on them. These theories should not be accepted by the community since they are not proved yet. But after they are tested with many experiments and are confirmed, they become laws which are certainly true" (P7).

The scientific laws were seen to be placed at the top of this hierarchy by the participants, as the knowledge of the facts which are certainly true in all cases. This approach was also seen to be informative for the participants' conceptions about the structure and the testing process of the theories. The idea of the confirmation of the theories by the experiments indicated that they conceived theories as some type of guesses which can be directly tested. They seemed to not have informed views about the structure of scientific theories and their roles in research. They thought that they learn theories, even the changed or rejected ones, to see their failures and to have the chance of evaluating the current ones.

These naive views about scientific theories and lack of information about their guidance in research were also indicative for participants' conceptions about scientists as observers. It was seen that a minority of participants (17%) presented informed views about the theory-laden nature of observations, which was not surprising in the whole group, where majority of the participants portrayed science as a process of proving of the facts. The scientists were presented as blind minded researchers who are free from all the personal and cultural values/beliefs by this majority of the participants, as seen in their discussions about the dinosaur extinction controversy:

> "Although two different views exposed in this controversy, I think the problem here is the time period they are talking about. It was a long time ago and we cannot be sure what happened at that time. But, when enough data is found one of them will be accepted" (P21).

The participants emphasized mainly the lack of data as a reason for such a controversy and the impossibility of being sure about an issue that happened a long time ago, but did not exhibit any understanding of the role of prior knowledge and scientific theories which influence scientists' interpretation of current evidence.

The majority of participants' (80%) understandings about the models, the structure of atom in this case, were also seen to be naive, which also presented some cues that reflected their views about the creative and imaginative NOS. The participants indicated that scientists are generally sure about the structure of atom, as they performed many experiments and gained data:

> "The scientists performed some experiments with alpha particles and collect data. They performed many such experiments, corrected previous failures and after that they become sure about the structure of the atom" (P19).

Although a limited portion of the participants (20%) asserted that the views about the structure of the atom should be altered in the future with the advance of technology, the reason they proposed was seen to be based on having some additional data. The creative and imaginative aspects of NOS (in the construction process of the models and theories) were not explicitly emphasized in any of the participants' responses. The general tendency was to discuss the scientific models as constructs that represent the reality as it is. The use of creative and imaginative NOS by the great portion of the participants (70%) was seen to be limited with designing of the experiments to collect data, as a step in the process of scientific research.

The participants' discussions about the universality of the science, finally, were seen to be informative for their naive understandings about many aspects of the NOS. Nearly all the participants asserted a "universal science" understanding, which is totally free from social and cultural values, at least as an end product. Although some of the participants (23%) gave credit to the role of socio-cultural factors in the scientific enterprise, their comments were mostly related to the motivating aspect of these factors for scientists:

> "A research area can be supported in some countries whereas forbidden in the others. Socio-cultural values can direct the interests of the scientists or the distribution of the funds. However, they cannot be determinant in the process of research, for the acceptance or rejection of results" (P18).

The main rationale that frequently observed in the participants' responses for the universality of science was seen to be based on the objective reality it examines. They stated that science is about the facts, which are the same everywhere, and mainly gave the sample of the free fall of a mass. It is noted that all the masses will fall down, when dropped, in the same manner on the earth wherever you are. The common failure of the participants in this context was seen to be about the discrimination between the objectivity of the phenomena that scientists examine and the science itself as a complex process. As a result, they could not exhibit an informed understanding about science as an enterprise which is embedded in a socio-cultural milieu that impacts the NOS.

PARTICIPANTS' TACIT NOS UNDERSTANDINGS

The qualitative analysis of the activity sheets prepared by the participants to demarcate science from pseudoscience implied that the majority of the participants portray a general view of science which based on the discovery of physical phenomena without any interpretation. Solely, direct observations or experimentations of "facts" without any inferences such as buoyancy and expansion of metals were seen to be viewed as doing science by them.

The activities planned by the participants were seen to be grouped into two according to their strategies for developing an understanding of demarcation of science and pseudoscience. The first group (60%) was directly focused on the comparisons between scientific knowledge claims and pseudoscientific ones. The generally used scientific knowledge claims in this group were about directly observable and sensible physical phenomena, such as the expansion of heated metals. The contrary pseudoscientific ones in these comparisons were mostly astrological claims, such as the behavioural properties of individuals related to their astrological signs. The following example should be viewed in this manner:

> "Firstly the students in the class will perform an experiment about the expansion of the heated metals. They will take a piece of metal rod and measure its initial length and temperature. Then they will heat it and again measure its current length and temperature. In the last step, they will compare its initial and last length in accordance with the increase in its temperature. They will see that the scientific knowledge about the expansion of heated metals is proved by this experiment. In

> the second phase, the students will be asked to write their behavioural properties and date of birth on a piece of paper. Then these papers will be collected and grouped according to the dates of birth with the help of students. In the next step they will be examined to determine if the behavioural properties are directly related to the dates of birth. The students will realize that the claim of astrology for such a relation is inaccurate and pseudo" (P28).

The other sample activities planned in this first group were also seen to be very similar in their nature. The scientific units in the comparisons were based on either direct measurements or observations of objective phenomena such as the boiling of water at 100^0C. However, the pseudoscientific units were astrological claims including subjective constructs such as behavioural properties which tried to be questioned with the students in the class. These activities had indicated that the participants had perceived the scientific claims as absolutely true and strictly verifiable. Objective, reproducible and directly sensible matters of facts were thought as the only scientific without any emphasis on any conceptual or theoretical entity. Such an approach was seen to strictly bound science to a narrow, naive understanding which should be a source of crucial misperceptions about scientific enterprise.

The second group (40%) was seen to be more flexible for the comparisons they planned and took the units to be examined as disciplines rather than individual knowledge claims. The general tendency was determining some criteria for demarcation of science from pseudoscience and evaluating sample cases, such as alternative medicine and acupuncture, according to these criteria in class with the students. They planned to ask students a search for possible criteria of demarcation which then intended to discuss in the class to develop a common list. With the use of such a list of criteria, either small group discussions or whole class discussions on provided sources, such as texts about various fields of inquiry or videos, were designed.

> "I will ask students to search the properties of science and after they develop a list of criteria for being scientific, they will discuss them in small groups in the class. Then, these lists which will be developed in small groups will be discussed in the class as a whole and a final list of criteria will be determined. I will guide the students in the discussions and will provide them a sample case, alternative medicine, to be examined for being scientific according to the list of criteria developed in the class... Students will realize that alternative medicine is not accepted as scientific by the whole community and does not have powerful experimental support" (P 6).

Although this approach was seemed more powerful to develop a demarcation understanding for elementary science students, the fuzziness in the criteria to be determined and the inadequacy of the portion of this group to whole were evaluated as problematic. The participants either did not label any sample criteria for demarcation or listed objectivity, universality and experimentation as determinants of science or mainly highlighted the products of the disciplines to be examined according to these criteria. Any sign of perspective about the processes which the disciplines occupied while generating knowledge claims and about their ontological and epistemological assumptions were not seen in these activity plans. So, although the activities planned by the participants in this study were grouped into two according to their strategies, the rationale in their approaches for a discipline or individual knowledge claim to be scientific were seen to be similar.

CONCLUSION

The results of the research implied that participants' explicit NOS understandings were naive especially for the aspects; (i)theory-laden nature of observations, (ii)socio-cultural embeddedness of scientific knowledge, (iii)the myth of a universal scientific method and (iv)the roles of hypothesis, theories and laws in scientific enterprise. An absolutist view of scientific knowledge in a belief-free context that can be gained through a universal, unique scientific method involving a set of fixed stages was seen to be central in participants NOS understandings. The tacit understandings emerged with the analysis of activity sheets were seen to be in accordance with these explicit ones and portray a general view of science based on discovery of physical phenomena without any interpretation. Solely, direct observations or experiences of "facts" without any inferences such as buoyancy and expansion of metals were seen to be viewed as scientific activities by a majority of the participants, which is subject to the absolute confirmation. So, the results of the research indicated that participants' tacit understandings seemed to form the basic rationale for their explicit views which should be examined further by the help of activities planned by them to have a chance of developing naive beliefs. Within such a process, the participants should be provided with explicitly discussed NOS aspects that based on the reflections of their tacit understandings. The development of tacit understandings in action would then be transferred into explicit interpretations of NOS.

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LEARNING TO CONNECT DIFFERENT CONTEXTS: NEW PERSPECTIVES THROUGH KNOWLEDGE TECHNOLOGIES

Maja Bračič Lotrič

University of Nova Gorica, Slovenia

maja.bracic.lotric@ung.si

Tanja Urbančič

University of Nova Gorica, Slovenia

tanja.urbancic@ung.si

ABSTRACT

Understanding complex phenomena and solving difficult problems requires not only specialized scientific knowledge, but also cooperation across the borders of disciplines and particular contexts. In this paper we discuss why connections across different contexts are important, how knowledge technologies can help in recognizing and establishing these connections, and how we prepare our students for such tasks. Recent technical solutions have potential of becoming general methods for coping with increasing amounts of specialized knowledge. As such, they should become a part of a methodological repository for students and professionals in all fields of science. At the same time, students should know that technical solutions go hand in hand with non-technical development, so this should be taken into account in developing curricula. Some solutions implemented in the Engineering and Management Master's study programme are presented and analysed, including three year experience with student projects, characterized by an open concept, encouraging creativity and development of skills needed for problem solving.

Keywords: *Education, problem solving, creativity, curriculum, knowledge technologies*

INTRODUCTION

Nowadays, professionals in science and all sectors of industry are faced with overwhelming amounts of information. The information volumes relevant for a particular field grow perpetually in an exponential manner. At the same time, our society is facing many complex problems which require up-to-date knowledge from different disciplines to be taken into account, while available time and resources for solving problems are often limited. Consequently, one of the most important challenges, not only for scientists, but also for engineers, business managers and students, is the effective retrieval and use of information for valuable knowledge discovery.

It is therefore very important to teach the students – future scientists, engineers or managers – how to deal with huge amounts of knowledge available on-line, how to find a way to useful fragments of knowledge, how to connect them and use them to solve the problems (Burns, 2006). In education system, the prevailing emphasis is on mastering well-defined corpus of knowledge, while teaching students how to acquire newly developed and dispersed knowledge by themselves is often neglected. In general, schools also don't teach students about knowledge technologies which could support them in this process (Urbančič, 2007).

In this paper we discuss why and how education programmes could improve the situation. We also present how students' creativity and their ability of recognising, formulating and solving problems is developed in the Engineering and Management study programme at the

University of Nova Gorica. Further, we present a novel tool which enables to link knowledge from different fields. This tool has already proved to be useful in research work and may help students in their project work and thesis preparation in the future.

CREATIVITY THROUGH CONNECTIONS ACROSS CONTEXTS

To find creative and innovative solutions, it is important to connect not only facts and information from different contexts, but also different ways of thinking and problem solving. Several studies can be found in literature confirming the relevance of this ability. They include associations across different contexts, named bisociations (Koestler, 1964), examples of engineering inventions inspired by non-technical sources of ideas (Ferguson, 1994) and a study confirming that people connected across groups are more likely to express their ideas (Burt, 2004).

BISOCIATIONS

Information that is related across different contexts is difficult to identify with conventional associative approaches. The context-crossing associations, however, are the ones often needed for innovative discoveries. Such associations are called bisociations (Koestler, 1964). According to Koestler theory, a bisociation connects two concepts from commonly unrelated domains by observing them from a particular, innovative point of view. Bisociations have the potential of generating new discoveries, by enabling the entirely new cross-disciplinary connections among concepts from those contexts that are normally considered as distinct categories. Besides scientific discovery, the bisociations can enhance also the humour creation techniques and inspire the artists to create original works of music, theatre and art (Koestler, 1964).

Mednick (Mednick, 1962) defined creative thinking as the ability to generate new combinations of distant associative elements (e.g., words). He explained that thinking of concepts, which are not strictly related to the elements under research, inspires unexpected useful connections between elements and thus considerably improves a creative process. Actually, marginal observations are not necessarily characterized by mistakes or inaccuracies but may provide an indication of valuable information (Barnett and Lewis, 1994). From this point of view, creative thinking constantly involves a process of evoking latent possibilities to discover new useful information and unforeseen knowledge.

COMBINING DIFFERENT WAYS OF THINKING

Engineering is nowadays generally treated as derived from science. This assumption, however, ignores many nonscientific decisions, made by technologists as they design the world we inhabit (Ferguson, 1994). The emphasis is given to knowledge that can be expressed as mathematical relationships. Increasing computer power and improved models enabled for quick analyses. The computers apparent precision can give engineers an unwarranted confidence in the validity of the resulting numbers. Many modern schools produce graduates who are not fully aware of the myriad subtle ways in which the real world differs from the mathematical world taught in classrooms. Such engineering education may result in a shock to students when they discover that their decisions can not be based solely on mathematical calculations (Ferguson, 1994). Nonverbal expert knowledge can not be fully acquired during the studies, but it is essential to show the students the importance of such knowledge.

CONNECTIONS ACROSS GROUPS

Burns's (Burns, 2004) hypothesis is that people who are connected across groups are more likely to have good ideas. Namely, the behavior are more homogeneous within then between groups, so people connected across groups are more familiar with alternative ways of thinking and behaving, which gives them more options to select and synthesize from alternatives. Ideas come from a variety of paths from a variety of sources and often ideas are generated by moving knowledge from one group to another, or combining knowledge across groups.

Brokerage between industries, technologies or markets can be successfully used by companies. A company with clients in diverse industries may use technological solutions from one industry to solve client issues in other industries, where the solutions are rare or unknown. For example, as discussed in (Burns, 2004), the Hewlett-Packard company policy was to move engineers between projects. The result was that HP technologies were constantly mixed in new combinations. Similar results are available across organizations: higher company performance is reported when top managers have boundary-spanning relationships beyond their firm and beyond their industry. Brokerage may be considered as a capital and even venture-capital firms, spanning structural holes by linking co-investors not otherwise investing together, are reported (Burns, 2004).

PUTTING FRAGMENTS OF KNOWLEDGE INTO A BIGGER PICTURE

The process of identifying appropriate pieces of knowledge and putting them together to solve a problem at hand can be supported by several knowledge technologies. These include text mining (Feldman, 2006) and construction of ontologies (Joshi and Undercoffer, 2004). Here, we concentrate on a novel literature mining method RaJoLink (Petrič et el., 2009) which supports "finding the seeds of future discoveries in nowadays literature" (Urbančič et al., 2009) by suggesting candidate hypotheses and possible ways towards supporting evidence for these hypotheses.

RAJOLINK METHOD

The RaJoLink method was designed and implemented at the University of Nova Gorica by Petrič et al. (2009). It is based on Swanson's model of knowledge discovery (Swanson, 1990). Swanson regards scientific articles as clusters of somewhat independent sets of literatures, where common matters are considered within each set. He calls non-interactive those literatures that do not cite one another, that have no articles in common, and that are not cited at the same time by other papers. According to his proposal, such distinct unrelated literatures could be linked to each other by arguments that they treat. Consequently, if two literatures can be logically related by arguments that each of them addresses the unobserved connections between them represent potential sources of new knowledge. For instance, if literature *A* (i.e. a set of all available records about *a* in the database serving as a source of data) reports about term *a* being in association with term *b*, and another literature *C* associates term *c* with term *b*, we can thus assume literature *B* to be an unintended implicit potential connection between literatures *A* and *C*.

The RaJoLink method involves three principal steps, *Ra*, *Jo* and *Link*, which have been named after the key elements of each step: searching for rare terms, joint terms and linking terms. The three steps are presented as procedures of the RaJoLink method in Figure 1.

In step *Ra*, the literature about phenomenon *c* (i.e. the domain under investigation) is examined. The aim of this step is text analysis of the literature about phenomenon *c* in order to identify interesting terms that rarely appear in literature C, (i.e. the documents about phenomenon *c)*. In step *Jo*, separate sets of documents about the selected rare terms are inspected and interesting joint terms that appear in the intersection of these sets of documents about rare terms are examined. At least one of them is then selected as the candidate for *a*. The relationship between phenomenon *c* under investigation and a candidate joint term *a* represents the hypothesis generated in the open discovery part of the RaJoLink method. In step *Link*, which implements the closed discovery, linking terms *b* that bridge the gap between the domain *A* and the domain *C* are searched for. Relations between literature *A* and literature *C* are established with pairs of documents that contain *AB* and *BC* relations. Finally, the user has to evaluate the *AB*, *BC* pairs of documents in support of the generated hypotheses about the relation between the domain *A* and the domain *C*.

The method is implemented as a user-friendly computer program which has been used as a tool supporting researchers in their process of searching for new connections between concepts in biomedicine (Petrič et al., 2009; Urbančič, 2007).

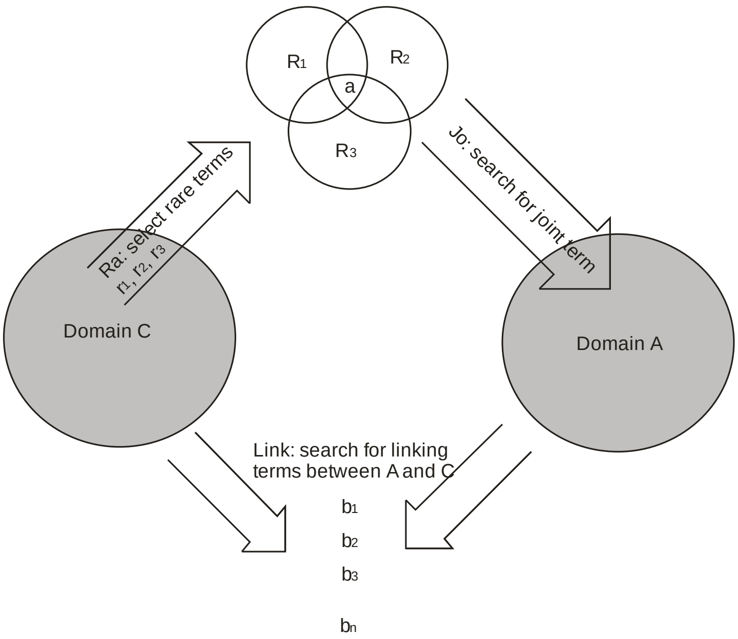

Figure 1: Procedures of the RaJoLink method.

HOLISTIC APPROACH

In solving problems in real life, people often collect ideas and information and put them together. But in many cases it is difficult to say when the picture is complete while reliable information regarding the whole picture is missing. The ability to recognise the whole is crucial not only for successful problem solving but also for successful problem definition. Actually, problem definition is the most difficult thing to teach (Burns and Jordan, 2006).

The holistic system thinking is the way to see the whole system (Burns and Jordan, 2006). Science and engineering fields incorporate holistic thinking as a natural part of students' development. Some fields explicitly teach modelling skills by starting at simple models and then adding variables successively to increase the explanatory capability of the model. Business problems, on the other hand, are more difficult since they do not have clearly defined boundaries, components and interactions in the models. These skills can be developed by special techniques, including case studies, simulations, learning by doing and gaining experience under supervision.

IMPLICATIONS FOR EDUCATION

In engineering study programmes, the prevailing emphasis is on engineering knowledge and skills. Besides highly specialized individuals, industry and other employers need also professionals with capabilities of connecting technological, economical and organizational aspects needed for success of an enterprise. It is a big advantage for engineers to understand the connection between technical solutions and their economic aspects, and also to be prepared to work in interdisciplinary teams (Gider and Urbančič, 2010). One of the study programmes preparing students for this kind of jobs is also Engineering and Management at the University of Nova Gorica. Lack of this profile may be indicated by the fact that employability of graduates at this programme in one year after graduation is over 95%.

While preparing the curricula, especially for post graduate students, special attention was paid to developing their ability for problem definition and problem solving. The profile itself is defined as interdisciplinary. The basic knowledge from different fields should give students solid background for connecting information across contexts. As the programme is spanning over technology and management, the combination of these two fields comprises two rather different ways of thinking: while technology favoures analytical approach, the decisions in management are not based only on analytic methods, but also to a great deal on intuition and experience. Taking this starting position into account, we wanted to include issues such as how to see a problem as a whole, how to actually find knowledge relevant for a given problem, and how to use it for problem solving. The best way to teach such skills is gaining experience under supervision (Burns and Jordan, 2006). In light of the view that developing skills for team work and open problem solving without direct instructions should be supported throughout education at all levels (Gider and Urbančič, 2010), student project work was introduced to the programme.

STUDENT PROJECTS

The curriculum of master's programme Engineering and Management includes

- "team project", held in the first year and
- "individual project" in the second year.

The students' work and progress is in all stages supervised by the project coordinator and in the case of individual project also by the individual supervisor. The projects were launched in the 2006/2007 (team) and 2007/2008 (individual) academic year.

Team project

The idea of the team project is to give the students opportunity to gain experience with an extensive project where different skills are needed, e.g. team work, coordination of work, project management, research, problem solving, public presentations, time management etc. The course gives the students hands-on experience of the work on a project which is very close to the reality, thus developing several important skills that cannot be obtained through the usual »ex cathedra« learning style. Students are forced to gain the experience in team work, and to overcome the uncertainties and obstacles which arise in such projects (Gider and Urbančič 2010). The project encompasses generating ideas as well as validation of these ideas from different points of view (technological, economical, social etc.). In this way students also learn that single problem may be seen in various ways.

Individual project

The individual project introduces the concept and methodology of scientific research to the students. As a firs step, students are expected to search for valuable information by themselves. In this way, they not only improve their knowledge and skills in the project-specific area, but also learn about general approaches to problem solving. The emphasis is not solely on gathering and connecting information to get new ideas (Figure 2), but also on their ability to see the problem as a whole. Only by having the whole picture in their mind, they can search for the missing parts. Creating a complete frame of a given realistic problem is a rather complex and complicated task, therefore each student works under supervision of a specialist for the field in question.

The projects are typically interdisciplinary and students are encouraged to find and define the problems. Especially students with work experience prefer searching for problems to solving pre-defined problems. In this way, benefits are multiple: for the student who gains experience in problem solving, for the companies which get solutions of their problems, and also for the university which gets valuable information regarding existing "real world" problems.

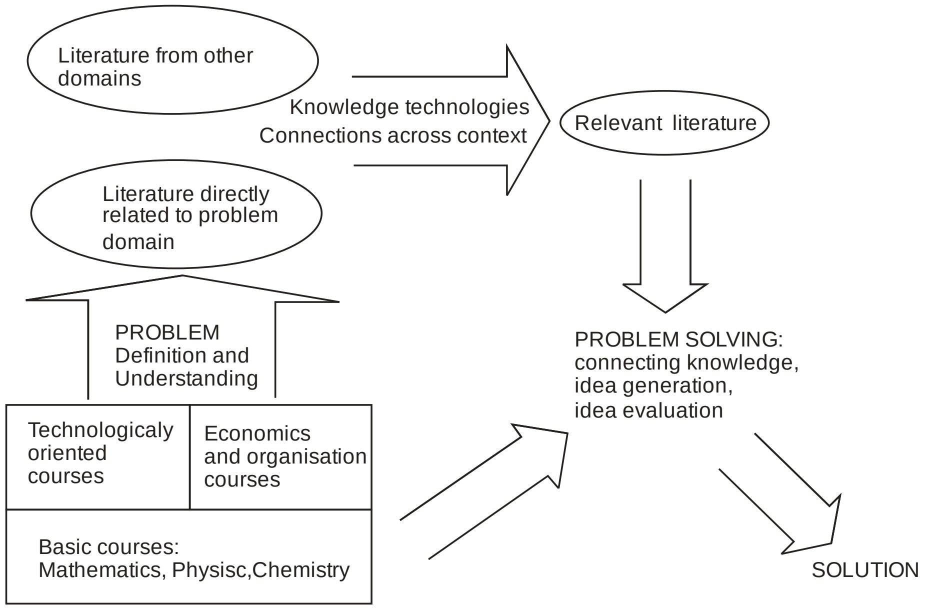

Figure 2: Connecting knowledge to solve complex problem during students work in individual project.

ANALYSIS OF INDIVIDUAL PROJECTS

During the last three years 38 students took the subject and 33 final reports were analysed. 21 projects were based on concrete problems from companies, while the remaining 12 were more general. From 33 accomplished works, in 20 cases the theme was proposed by the student. From the rest 5 students, who have not yet finished their work, only 1 theme was proposed by the student. This reflects that students with higher initiative are also more successful.

Table 1. Number of papers spanning over different fields.

	Management	Product & tech.	Energy	Quality	Environment	IT & optimisation	web	No. of papers from this field	No. of papers connecting this field with any other field
Management	4	5	1	2		1	1	14	10
Product & technology	5	5	1		3	1	2	17	12
Enerergy	1	1			4			6	6
Quality	2							2	2
Environment		3	4			1		8	8
IT & optimization	1	1			1	1	1	5	4
Web	1	2				1		4	4

By analysing all texts, several common key words were found: management, technology, energy, quality, environment, information technology, optimisation methods and web. 24 projects spanned over at least two fields. Interactions are presented in Table1. Numbers on diagonal present papers which include only one field. In 3 cases students have linked three of these fields. The last two columns give the numbers of papers where the field is included and the number of papers where it is combined with at least one of the others.

When evaluating creativity we have followed the Mednick (Mednick, 1962) definition of creative thinking, i.e. creativity is the ability to generate new combinations of distant associative elements, only to a limited extend. At this stage of study, we prefer to grade the ability of students to define and to solve the problem on their own. 20 out of 33 students were able to detect and define the problem alone based on their knowledge and observations. In solving the problem, however, the help of supervisor was crucial for almost all students. If we rank the creativity form 1 to 5 (1: no student initiative, 2: knowledge collection with no added value 3: conclusions selected from knowledge collection 4: student is able to find new solutions with suggestions, 5: student was able to give new combinations), the average value is 3,4. This shows that the majority of students are able to apply existing solutions of similar problems to solve their own problem, but they did not exhibit higher levels of creativity.

We also examined students ability of finding relevant literature. Here, again, students were ranked 1 to 5 (1: inadequate literature, 2: mainly web literature, 3: web with basic books, 4: web, books and basic papers, 5: up to date papers and books). The average value of 3,1 reflect the problem that students rely mainly on web resources while they do not search for up to date research papers.

The experiences with the project work so far are encouraging, however, there is still room for improvement. Based on the presented analysis, the weakest point at this stage is the phase of knowledge discovery. During this time, the RaJoLink method was developed and tested in non-trivial biomedical domains (Urbančič et al., 2007, Urbančič et al., 2009) to an extent which allows it to be recommended to students as a useful tool. Also, more emphasis should be put on the ability of holistic thinking. Since it has been observed that students with higher initiative have been more successful, we will more consistently encourage their initiative.

CONCLUSION

In our complex world, it is sometimes a great challenge to find the right knowledge or technology to solve a given problem. In overcoming the difficulties related to this problem, knowledge technologies can serve as a very useful tool. We believe that similarly as learning computer skills started its way to education at all kinds and levels a couple of decades ago to become generally accessible and assumed knowledge for everybody nowadays, learning knowledge technologies will find their way in schools in the forthcoming years.

In the Engineering and Management study programme at the University of Nova Gorica, there is a strong emphasis on interdisciplinarity and creativity. Therefore, courses from different fields which also stimulate different ways of thinking are included in the curriculum. During their project work students practise connecting knowledge from different fields and resources to solve a given problem under supervision. We believe that this kind of training helps the students in their further careers.

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TEACHING SCIENCE AND TECHNOLOGY AT PRIMARY SCHOOL LEVEL: THEORETICAL AND PRACTICAL CONSIDERATIONS FOR PRIMARY SCHOOL TEACHERS' PROFESSIONAL TRAINING

Juliette H. Walma van der Molen

University of Twente, The Netherlands

j.h.walmavandermolen@gw.utwente.nl

Sandra I. van Aalderen-Smeets

University of Twente, The Netherlands

s.i.vanaalderen-smeets@gw.utwente.nl

Lieke J.F. Asma

University of Twente, The Netherlands

l.j.f.asma@gw.utwente.nl

ABSTRACT

This paper focuses on the importance of starting science and technology education at a young age and at the consequential importance of providing primary school teachers with enough professional background to be able to effectively incorporate science and technology into their teaching. We will discuss a large-scale program in The Netherlands that is aimed at the professionalization of elementary school teachers in the field of science and technology. Theoretical and practical considerations will be provided for the three pillars that ideally should be included in teacher training programs in this domain: (1) Primary school teachers' knowledge of and competency in scientific concepts and scientific reasoning; (2) Primary school teachers' attitude towards science (in terms of cognitive, affective, and behavioural dimensions of attitude); and (3) Primary school teachers' pedagogical competency to enhance inquiry-based learning.

Keywords: *S & T teacher education; Primary school teachers; Policy initiative; Teacher professionalization.*

INTRODUCTION

Despite the fact that in society today, we are becoming increasingly dependent upon science and technology on a number of fronts, much of the population has little scientific or technological knowledge and the image of a professional career in the natural sciences and technology is not very positive. Although various measures have been undertaken to attract more students in science and technology studies, the interest in these disciplines has declined further among young people over the past decade (de Grip & Smits, 2007). While this lack of interest in science and technology often only manifests itself when young people must choose their high school study subjects, most students have already excluded the choice of a science or technology study long before this, during their elementary school period (Tai, Liu, Maltese, & Fan, 2006; Walma van der Molen, 2008).

How could this be remedied? In the Netherlands, a large scale project called the VTB Program (Broadening Technical Education in Primary Education) is designed to help primary schools integrate science and technology into their teaching. During a three-year period, schools receive financial, organizational and subject-specific support to put this into practice. By the end of 2010, 2,500 primary schools (one third of the total number) will have embedded science and technology in their education with support from the VTB program and regional support desks. The knowledge, expertise and experience developed and acquired by VTB schools will be made available to all primary schools in the Netherlands (see: http://www.vtbprogramma.nl/home/over-vtb/about-programme-vtb.html).

Although initiatives such as the VTB program have been reasonably effective, particularly where children's joy for science and technology projects is concerned, a major problem that cannot be solved simply by allocating more time to science and technology in primary education, is the fact that primary school teachers are not sufficiently trained to teach science and technology. International research (e.g., Palmer, 2004; Trumper, 1998) shows primary teachers' knowledge of science and technology and their attitudes towards science and technology to be generally low. Many elementary school teachers do not feel sufficiently prepared to teach science and technology, find it difficult to deal with the questions of students in this area, and rather fall back on highly structured text books (Skamp, 1991; Yates & Goodrum, 1990). Such practices lead to less than positive attitudes towards science and technology on the part of elementary school children, and to lower science and technology achievement (Harlen & Holroyd, 1997; Jarvis, 2004). There is, nevertheless a glimmer of hope. Research shows, for example, that when teachers are given greater knowledge, skills, confidence, and a more positive attitude via continuing education efforts, they subsequently teach science and technology in a better manner and can improve the knowledge, skills, and attitudes of their students in this area (e.g., Osborne, 2003; Osborne & Dillon, 2008).

The situation sketched above has led the Science and Technology Platform in the Netherlands to launch another large-scale program that is aimed at the professionalization of elementary school teachers in the field of science and technology (VTB-Professional or VTB-Pro program). The development of teachers stands central in this program, which offers a minimum of 5000 current and 5000 aspiring elementary school teachers a special training trajectory within the field of science and technology. The training program addresses three pillars of science and technology education: (1) Development of knowledge of key science and technology concepts in addition to key science and technology skills; (2) Development of more favourable attitudes towards science and technology; and (3) Development of the instructional skills needed to stimulate inquiry-based learning and learning by technical design.

The basic assumption within the program is that in order to genuinely and confidently address science and technology topics and projects within their everyday class situation, elementary teachers must first develop their own knowledge, attitudes, and inquiry skills within the field of science and technology in an open, exploratory, and reflective manner. The expectation is that when the teacher or aspiring teacher him/herself acquires greater knowledge, research skills, meta-cognitive skills, positive values, and confidence, he or she will also be in a position to provide more challenging, stimulating, inquiry-based instruction to his/her students.

For this purpose, it is important that the training offered to teachers be challenging, provides stimulating experiences, and devotes considerable attention to not only substantive knowledge within the field of science and technology but also to the image of science and technology, philosophical issues within the field of science and technology, a more positive attitude towards science and technology, and the promotion of one's own inquiry-based learning. The aim is to have the teacher and aspiring teacher participate in the learning process and learn to think, judge, decide, and act independently within the broad field of science and technology. In addition to this, attention must be paid to the embedding of science and technology in social and practical contexts.

This paper will discuss a number of theoretical assumptions that are argued to be of critical importance for the aforementioned professionalization of teachers. This will be done in terms of recent research in the areas of science education and attitude formation in addition to recent insights regarding inquiry-based learning and learning by design (i.e., constructivist learning). The specific theoretical assumptions will be complemented with different examples of potential implementations for the teacher training programs. The concepts will be considered in three separate sections of the paper that reflect the three pillars that are fundamental to the VTB-Pro program.

KNOWLEDGE AND SKILLS WITH RESPECT TO SCIENCE AND TECHNOLOGY

In order to identify the knowledge and skills for teachers to acquire, a clear view must first be attained of what can be understood under science or science and technology. In a recent report from the European Commission ("Science Education Now: A Renewed Pedagogy for the Future of Europe," which is better known as the Rocard Report, 2007), both the natural sciences and technology are described as systems of knowledge that attempt to model objective reality. For the current discussion, the preceding has been translated as follows:

> Natural science and technology are ways to acquire and apply knowledge on the basis of not only the methods of natural science and technology but also the structured whole of knowledge and skills resulting from this.

Of fundamental importance for the substantive description of the knowledge and skills that are of specific relevance for science and technology education, is recognition of the fact that a dichotomy characterizes the field: on the one hand, there is the *knowledge* of *concepts*; on the other hand, there is the *manner* in which such knowledge is acquired. For technology, one can also speak of the additional use of knowledge for design and manufacturing purposes.

The aforementioned dichotomy has also been described in various other publications (e.g., Harlen, 1999; OECD/PISA, 2006). Some publications refer to knowledge *of* science and technology as opposed to knowledge *about* science and technology, while other publications refer to knowledge of scientific and technological concepts as opposed to knowledge of scientific and technological process skills. Of particular importance, however, is that these elements *together* constitute a system of knowledge and skills within the field of science and technology, and that the elements should be considered in conjunction with each other for the professionalization of teachers and aspiring teachers. In the following, the elements will be considered further.

Knowledge of concepts

It is not easy to describe the key knowledge components within the field of science and technology unambiguously. In the OECD/PISA study, "knowledge of science" was divided into four categories: knowledge of natural science systems, knowledge of living systems, knowledge of the earth and space systems, and knowledge of technical systems. The descriptions presented in the study itself come mostly, however, from a natural science perspective and encompass very few contexts of relevance for young children and their teachers.

Nonetheless, the PISA classification — which goes back to the "Science Standards" from the USA in 1996 — allows us to formulate some critical concepts more precisely. The four initial systems can also be expanded to include a fifth category, namely mathematical systems. And the different categories (i.e., systems) can next be characterized in terms of the concepts indicated below.

Physical systems*.* Where attention is devoted to concepts such as: 1) features of objects (whether natural or constructed); 2) position and movement of an object in space and time; 3) force and motion; 4) energy or the capacity to cause change; 5) transformation of energy; 6) radiation, such as light, warmth, radio frequencies, x-rays; or 7) electricity and magnetism.

Living systems. Where attention is devoted to concepts such as: 1) the cell, organ, and organism; 2) man, plant, and animal; 3) respiration, circulation of blood, and digestion; 4) life cycle and reproduction.

Earth and space systems. Where attention is devoted to concepts such as: 1) the structure of the lithosphere, hydrosphere, and atmosphere; 2) the soil, mountains, stratification, change (erosion), and tectonics; 3) water, including the ocean, sea, lakes, rivers, canals, tide; 4) air, including the atmosphere and stratosphere; 5) climate and weather; 6) history in the form of fossils; 7) the earth *in* space including the structure of space with respect to earth, moon, sun, and stars in particular; and 8) gravity.

Technical systems. Where attention is devoted to concepts such as: 1) construction, facilitation, and progress; 2) design, including criteria, limitations, innovation, invention, problem solving; 3) transformation of energy, function, materials; 4) facilitation of a better life and scientific progress including information and communication technologies, games, medical systems, traffic safety systems, and navigation tools and instruments among other things.

Mathematical systems. Where attention is devoted to concepts such as: 1) quantities, including numerical phenomena, quantitative relations and patterns, "number sense", and logical operations; 2) form and space including spatial orientation, navigation, representation, forms, and figures; 3) changes and relations including correlations, diagrams, tables, types of change (e.g., linear or constant); and 4) uncertainty, data, and chance.

When considering these knowledge concepts, it is important that considerable attention be paid to the cross-connections between these systems in the composition of the teacher-training program. Structural knowledge of concepts from different domains only emerges when individuals learn how two or more concepts relate to each other and how different systems occur within certain themes. In addition, special attention should be paid to how the mathematical system appears in all of the other systems.

In the application of the mathematical concept of quantity, it is important — for example — to see that important aspects of this concept, such as an understanding of relative size and the recognition of patterns in data, occur in virtually every branch of science and technology. *Patterns* occur and can thus be detected in language, music, video, traffic, buildings, art, and nature. The concept of "form and space" can be seen in the *forms* that are visible all around us: houses, bridges, snowflakes, maps, crystals, shells, plants, and the universe. The mathematical concept of "changes and relations" points to the fact that every natural phenomenon is, in fact, the manifestation of a change and that innumerable examples of relations between phenomena can be perceived in the world around us. Organisms grow; change can be continuously perceived in the seasons, the tide, and the weather; there is development in the quickness of computers and air pollution; and much, much more. To close, it is important to emphasize that the mathematical concept of "uncertainty" also appears, in fact, in all of the scientific and technological disciplines. Scientific and technical knowledge is always the product of a process in which uncertainty (i.e., chance) cannot be excluded: Bridges collapse, the weather is often different than expected, air pollution is worse than predicted, and unjust convictions sometimes occur on the basis of unreliable data.

The aforementioned illustration highlights the importance of not only emphasizing the cross-connections between concepts in the teaching of scientific and technical concepts, but also taking the *relevance* of what is learned as the starting point for the supplemental training of teachers. Given that many teachers (and their students) are not familiar with many technical and scientific concepts, this gap must be bridged via the connection of abstract concepts to *clearly recognizable and relevant contexts*. Relevance can be found in the personal sphere, daily professional practice, the neighborhood, society, or — for instance — further study. With the use of clearly recognizable contexts, it can also be made clear that one and the same concept can play a role in widely differing contexts and systems (Waarlo, 2007). By making these connections and any changes of meaning explicit, the transfer of conceptual knowledge can be expanded and comprehensive knowledge within the broad domain of science and technology can emerge.

Scientific process skills
Within the domain of science and technology skills, the scientific method stands central. The following elements play a critical role in the scientific method: asking the right question (i.e., a scientific question born out of curiosity), sufficient justification of one's question, identification of relevant information, design and conduct of experiments, measurement including insight into the degree of uncertainty in the data, and critical evaluation of the results. In addition, hypotheses, logical reasoning, and critical reflection play an essential role. Stated concretely and based on Harlen (1999), the following can be understood as critical science skills:

- **observation**: a fundamental skill that allows people to select information via the use of all senses;
- **drawing of space-time relations**: learning to judge how much time an event takes and the volume or area that an object occupies;
- **classification**: recognition, identification, sorting, and ordering according to similarity or difference;
- **hypothesis formation**: on the basis of consistent, general information from observations and other data, explication of those assumptions that can possibly explain a given occurrence or observation;
- **prediction**: the formulation of the results of a study in advance (i.e., on the basis of a given hypothesis);
- **experimentation**: the testing of hypotheses via actual research using carefully controlled circumstances and methods;
- **manipulation and control**: the imposition of systematic conditions and determination of whether these produce the intended effect or not;
- **measurement**: determination of sizes, time, areas, speed, weights, temperature, volume, etc.;
- **analysis**: the distinction of meaningful (i.e., systematic) information from noise and insignificant artifacts;
- **conclusions**: the drawing of conclusions on the basis of all the observations and data collected in order to evaluate the hypotheses put forth;
- **interpretation**: attempts to understand the data collected and connect the conclusions drawn on the basis of this data to other data and ideas;
- **communication and dissemination**: one should be able to present that which was discovered or observed in a powerful manner using various media.

Technical process skills
Under technical skills, one can think of practical reasoning that occurs in addition to theoretical reasoning. Practical reasoning entails the capacity to reason means-ends

relations and the relations between the functions of a planned construction (i.e., artifact) and its physical realization or structure. These forms of reasoning constitute the components of the technical process of designing in which the skill of visualization also plays an important role. Just as for many scientific skills, technical skill is the ability to model reality and use physical models for this purpose.

The aforementioned skills — in conjunction with knowledge of the relevant concepts — should be included as a whole in the professionalization of elementary school teachers. In keeping with this, it is relevant that attention be paid to the philosophy of science and technology. Aspects of particular importance are: 1) recognition that the different sciences constitute “lenses” that can be used to view reality and 2) recognition that there are, for this reason, different sciences: such as, the social sciences, the liberal arts, and the natural sciences, which differ methodologically from each other. The philosophy of technology concerns predominantly the conceptualization of artifacts (i.e., manmade items), technical functions in contrast to biological functions, and the normative component of technological knowledge (i.e., prescriptive knowledge (de Vries, 2005). The interaction between technological and societal developments is also an important theme here.

ATTITUDES TOWARDS SCIENCE AND TECHNOLOGY

In the relevant research literature, the concept of “attitude” is construed as an internal, personal, psychological tendency to evaluate a particular object or construct in a positive or negative manner (Eagly & Chaiken, 1993). This personal tendency can persist for a longer or shorter period of time and involves cognitive, affective, and behavioral components. The *cognitive* component of the concept of attitude consists of *thoughts or opinions* about a particular object or construct. The *affective* component consists of *feelings and moods* with respect to a particular object or construct. The *behavioral* component consists of *actual behavior or the intention to do something or avoid doing something* with respect to the object of the attitude. In such a manner, a positive attitude with respect to learning or studying can consist of thoughts or opinions about the importance of learning for the attainment of a good job or a good future, personal feelings of pleasure derived from learning, or actual behavior in the form of studying hard or the intention to undertake a particular study.

Within the field of social psychology, attitude is traditionally seen to be one of the most important motives behind numerous processes and clearly related to motivation and interest. In keeping with this, attention to the notion of attitude in the literature on science education has strongly increased over the past few years. Critical in this regard, however, is the distinction between a scientific attitude and attitudes towards science (see Osborne, 2003). A scientific attitude manifests itself in the form of scientific thinking: curiosity, creativity, perseverance, critical reflection, and so forth. Such a scientific attitude was described in the outline of the necessary scientific process skills (see previous paragraph) and will also be considered in the section on inquiry-based learning below.

A different set of thoughts, values, feelings, and behaviors can be understood under attitudes *towards* science and technology — thoughts, values, feelings, and behaviors that address — for instance — one’s thoughts about the level of difficulty characteristic of the sciences and technology, the value attached to science and technology for society, feelings of pleasure or interest with regard to science and technology, and the desire or intention to learn more about science and technology. Considerable international research has shown that elementary school teachers often have little scientific and technological knowledge, and in addition have quite negative attitudes towards the natural sciences and technology (e.g., Palmer, 2004). These teachers do not like science and technology subjects and they hold low estimates of their capacity to teach these subjects, which often relates to negative experiences during their own elementary or high school education (Tosun, 2000). Such a negative attitude can lead teachers to devote less time to science and technology and may make it difficult to stimulate the knowledge, skills, and positive attitude of their pupils within the field of science and technology.

The situation described above is unfortunate, and it is important that the self-esteem, interest, and enthusiasm of teachers in science and technology be stimulated and supported. Research shows that such an endeavor can have a positive effect, not only on the teachers themselves, but also on the knowledge level and attitudes of elementary school students towards science and technology (e.g., Jarvis, 2004; Palmer, 2004). In addition to an integrated offering of knowledge and skills within the domain of science and technology and in addition to more insights in inquiry-based learning (which will be discussed in more detail in the next section), a very important (and often overlooked) element of the professionalization of elementary school teachers should thus be the explicit focus on teachers' own attitudes towards science and technology. It is important that teachers and aspiring teachers be aware of their own thoughts, values, feelings, and behavior in the field of science and technology. Such an awareness may be stimulated within teacher-training by paying explicit attention to the cognitive, affective, and behavioral dimensions of attitude, through:

- **discussion** (e.g., of the breadth and historical significance of science and technology within society)
- **reflection** (e.g., upon one's own elementary and high school education history within the domains of science and technology and a prior tendency to avoid learning or education in these domains)
- **training** (e.g., to provide new and positive experiences with regard to science and technology in order to increase teachers' pleasure and self confidence in the domain of science and technology)
- **lectures** (e.g., in which attention is paid to gender differences, stereotyped images of science and technology, and the lack of positive role models in science and technology for girls in particular)

PEDAGOGICAL SKILLS FOR INQUIRY-BASED LEARNING AND LEANING BY DESIGN

Science and technology education have their roots in Victorian England (1850-1900) where agrarian society made way for a society based on scientific and technological expertise. This new society could only be sustained with the training of people in science and technology. Disagreement existed, however, with regard to the exact nature of this education and, since that time, the form and content of science and technology education have regularly been the topic of debate. In the Victorian era, people were of the opinion that science education should be part of the education received in primary school. At that time, it was believed that such an education should be presented as "the science of everyday things" and thus aimed at the observation of nature: botany, zoology, physiology, and so forth. This perspective was concerned mainly with the establishment of knowledge and an understanding of the basic principles of natural science. Early in 1900, an alternative view of science education emerged. Thomas Huxley (1918, in: Osborne & Hennessy, 2003) viewed science education as predominantly a means for intellectual development. For Huxley, it was not so much the content of a particular science that was of significance but, rather, the unique capacity of science in general to train one's intellect.

Such discussions — of the importance of acquiring scientific content knowledge as opposed to mastery of the scientific thinking process — still occur today. Much of science and technology education in primary schools today, however, is still aimed primarily at the acquisition of so-called scientific literacy via the transfer of factual knowledge. Knowledge is seen to be a product of instruction, and the assumption is that having such knowledge will lead to a greater interest in and adoption of the values of science and technology. Research, however, has shown that the transfer of scientific and technological knowledge alone is not sufficient for the creation of a broader understanding of science and technology (Zint, 2002). During the past few years, we therefore see a renewed international plea for science and technology education that not only devotes attention to conceptual knowledge, but also promotes inquiry-based learning. This form of learning draws upon social-constructivist ideas about learning in which: knowledge is construed as a construct as opposed to a product, the learner him/herself must experience things, both context and social relevance are of importance, and a scientific attitude is developed.

It should be noted, however, that this inquiry-based learning often functions as ‘a magic word’ and that all kinds of projects within the context of “hands-on science” are considered as inquiry-based learning. As some authors have recently shown, this qualification is not always justified (e.g., van Graft & Kemmers, 2005; Rudolph, 2005). Children are challenged in most “hands-on” science projects primarily to work together on, for example, the building of a construction. Although such projects can realize a number of important objectives for science and technology education (e.g., collaboration, responsibility, reflection, observation, prediction, generalization), the fact that science is more about the construction of ideas than the construction of objects or machines is missed in these projects (Rudolph, 2005).

For the implementation of actual inquiry-based learning, it is thus important that not only “hands-on” but also “minds-on” science activities be undertaken and that inquiry-based learning be distinguished from learning to inquire (van Graft & Kemmers, 2005). Having students (children ánd adults) learn to do research and acquire the knowledge and skills relevant to the scientific method is generally understood under learning to inquire. For inquiry-based learning, in contrast, students must undertake an inquiry (i.e., research) to learn about *something else*. For inquiry-based learning, the conduct of research is a means; for learning to inquire, the conduct of research is an end.

In the field of science and technology, learning by design can be seen to play a role in addition to inquiry-based learning. Once again, the notion goes further than the aforementioned construction of an object or machine. By thinking more or less systematically about how the environment can be adapted to meet the needs and desires of people, children learn to think about not only the existing reality but also about other possible realities. Used in combination with the scientific method, learning by design is a manner to stimulate creativity. Just as inquiry-based learning, learning by design is a question of both “hands-on” and “minds-on” learning.

For the application of all of the above, the professionalism of teachers in the field of science and technology must be strengthened along two fronts. First, the *generic level* of knowledge and skills on the part of teachers must be strengthened by having them become more comfortable in the world of doing research in science and technology. This boils down to greater attention being paid within all disciplines to understanding the necessary concepts, the conduct of practice-based research, and the guidance of student research.

The second front for improvement is to strengthen the *specific competencies* of teachers for the guidance of student research within the field of science and technology. In fact, student research encompasses both inquiry-based learning and learning to inquire. And for teachers, this means learning to create a challenging learning environment and respond to the inquisitive questions of children in such a manner that their curiosity is satisfied and further stimulated.

The best way to teach teachers this is via “learning by doing.” In such a manner, they *themselves* actually experience what the empirical and regulatory cycle of production and application really means and how one can operate with regard to this. In such a manner, they also learn to adopt a scientific attitude in which curiosity, perseverance, appreciation of originality, creativity, responsibility, productive critique (including self-critique), and the adoption of an independent stance in one's thinking all play an important role.

When teachers have developed in such a manner, they can also develop the competence needed to impart science and technology concepts, skills and attitudes to their students in an inquiry-based manner. They can do this by having students look, listen, touch, smell, and taste (i.e., observe); encouraging them to ask more questions; having them try to predict what will happen; having them collect and use information from different sources that can range from rocks, sticks, and beetles to numbers, tables, and diagrams; stimulating them to seek and apply creative new applications for particular constructs; having them talk about their experiences and ideas using their own words; and having them examine those patterns that stand out in observations and measurements (Murphy, 2003).

For the aforementioned developments to occur, it is of importance that considerable attention be paid to *reflection* during the professional development of teachers. This includes not only personal reflection (e.g., Who am I? What are my capacities in the field of science and technology? What do I want to achieve in the field of science and technology?), but also reflection upon the learning process (e.g., What have I learned? How did I learn this? How can I apply what I have learned to my own teaching situation?). Such forms of reflection have the important objective of *empowerment* for teachers and aspiring teachers. In addition to enhanced self-confidence and instrumental professionalism within the domain of science and technology, such reflection increases the probability that teachers will continue to learn in a self-guided manner and stimulate colleagues to do the same.

DISCUSSION

In the above, a description was provided of the qualities that teachers and aspiring teachers should have for elementary science and technology education. It was argued that teachers should acquire knowledge of important science and technology concepts *and* the skills needed to gather such knowledge. It was also argued that a positive attitude towards science and technology is essential, and that the cognitive, affective, and behavioral aspects of such an attitude should be explicitly discussed and reflected upon during teacher-training. Last, it was contended that the most important didactic instrument to present science and technology in an inspirational manner is to foster inquiry-based learning and learning by design.

While these three pillars of science and technology education were discussed in three separate sections, it should be clear that they are closely connected. For instance, the principles associated with the third component of science and technology education — namely, the stimulation of inquiry-based learning and the concomitant assumption that learning can occur via exploration, asking questions, and self-discovery — are closely associated with the inferential knowledge and skills required for the scientific process. The attitude component can be viewed as a more comprehensive component that relates to both other components of science and technology education. Starting from the assumption that the attitudes of people determine their actions, thoughts, feelings, and choices to at least some extent, it can be asserted that having a positive attitude towards science and technology is just as important as, for instance, having a positive attitude towards reading. One can indeed learn to technically read to a sufficient extent, but only when a positive attitude towards reading has developed will one also read at one's own initiative and increasingly more for one's own pleasure. The foundation for a high quality professionalization program in the field of elementary science and technology education can be laid with the incorporation of all the aforementioned pillars into the program and making the connections between the different components sufficiently transparent.

In closing, it should be emphasized that strengthening the competence of teachers in the field of science and technology education can also enhance the level of teacher functioning *in general*. At its core, working on "the teacher as researcher" has a much broader spectrum than just the domains of math, science, and technology. When teachers learn to treat their own amazement and that of their pupils in a more systematic manner, this can also have significance for the domains of language, reading and writing, or the social-emotional development of students. By jointly going through processes, such as from perception to concept formation, from concept formation to causal relations, from causal relations to prediction, and from prediction to evaluation, teachers can help their students with the systematic solution of practical problems in all sorts of domains. In such a manner, working on science and technology education can serve a more general objective, namely improvement of the level of the teaching profession as a whole.

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INCREASING STUDENTS' INTEREST IN CHEMISTRY THROUGH COMPUTER-BASED MOLECULAR MODELING

Jenni Västinsalo

Helsinki University, Finland

jenni.vastinsalo@helsinki.fi

Maija Aksela

Helsinki University, Finland

maija.aksela@helsinki.fi

ABSTRACT

The present paper presents two case studies from the larger design research that aims at producing research-based molecular modeling material to be used to increase junior high school students' interest to study chemistry. The main research questions were: (i) how interesting do students find working with computer-based molecular modeling and (ii) how does the developed material affect students' interest. Altogether 118 junior high school students participated in this study. Survey and semi-structured group interviews were used as research methods. According to the results, computer-based molecular modeling is one way to improve the attractiveness of chemistry among young students. The students found molecular modeling interesting because (i) it offered some variety to regular chemistry lessons, (ii) it helped to improve the understanding of chemistry, and (iii) the students themselves had an active role. Working with computer was also highly valued. Students found molecular modeling fun, interesting, useful, and inspiring via the new study material on the gases of the atmosphere, which was used in the study.

Keywords: *information communication technology (ICT), molecular modeling, interest, design research, chemistry, chemistry education, junior high school*

INTRODUCTION

There is a lack of interest in chemistry among junior high school students. For example, a PISA-study has shown that students are not very interested in studying chemistry (Arinen & Karjalainen, 2007). Interest can be defined as a phenomenon that arises when individuals interact with their surroundings (Krapp et al., 1992). Over time situational interest can develop into personal interest (Hidi & Andersson, 1992). Many previous researches have shown that students are interested in working with computers (e.g. Lavonen, 2005). Published studies have shown that teachers and students generally have a positive attitude toward molecular modeling (e.g. Aksela & Lundell, 2008).

In Finland, there is not enough research-based material to be used in computer–based molecular modeling at junior high school level (Aksela & Lundell, 2008). The main aim of the larger design research study (Edelson, 2002) is to create material for chemistry education that can be used to increase students' interest in chemistry.

MODELS AND MOLECULAR MODELING

One goal of chemistry education is to teach students how to use and interpret models in chemistry, and how to understand their nature (Gilbert et al., 2000). Models link the scientific theories to practice (Gilbert, 2005). Chemistry education should provide students with tools to create their own mental models of the phenomena. Students exploit scientific models while building up their own interpretations (Treagust et al., 2002).

Chemical models are used in chemical research and education as a tool to explain, describe, and predict chemical concepts, processes, and phenomena (Barak & Dori, 2000). There can be several models to describe one phenomenon from different perspectives. Therefore the students should understand that a certain model is only one way to represent the phenomenon or concept from a particular perspective (Treagust et al., 2002).

Computer-based molecular modeling is a useful and flexible tool for chemistry education. A computer offers a quick and easy way to employ visual models, which are used to support verbal presentations. It is possible to visualize, adapt, and change existing models with modern molecular modeling, and use these models in multifaceted chemistry education (Aksela & Lundell, 2008).

RESEARCH GOAL AND POPULATION

The two case studies in question are part of a larger design research, which aims at producing research-based molecular modeling material that is used to increase junior high school students' interest to study chemistry. The design research study includes three stages: (i) an empirical analysis on the needs to develop the material, (ii) a study on what kind of material should be developed, and (iii) a study on how the material affects the students' interest. The first and third parts of the design research are presented in this paper.

There are two main research questions for this study:

- How interesting do students find working with computer-based molecular modeling?
- How does the developed material affect students' interest?

This study concentrates only on students' interest towards computer–based molecular modeling as a tool in chemistry education. The respective influence on learning was not studied, and the gender of the respondents was omitted.

Altogether 118 junior high school students participated in the study. In the first case study (problem analysis, see Figure 1), the population was 60 high school students. In the second case study (material evaluation, see Figure 1), the number of participants was 58. The students had no previous experience in computer-based molecular modeling, and they came from different parts of Finland. The students were randomly selected from the groups that took part in molecular modeling lessons at the Gadolin chemistry laboratory, which is a free learning environment for schools that operates in the Department of Chemistry of the University of Helsinki.

The developed molecular modeling material for studying the gases of the atmosphere was used in the second case study. Modeling was used as a part of a historical frame story. Throughout the story of the history of gases, the chemical phenomena and concepts were modeled with a computer.

RESEARCH METHODS

The research methods of two case studies from the larger design research (Edelson, 2002) are presented in Figure 1.

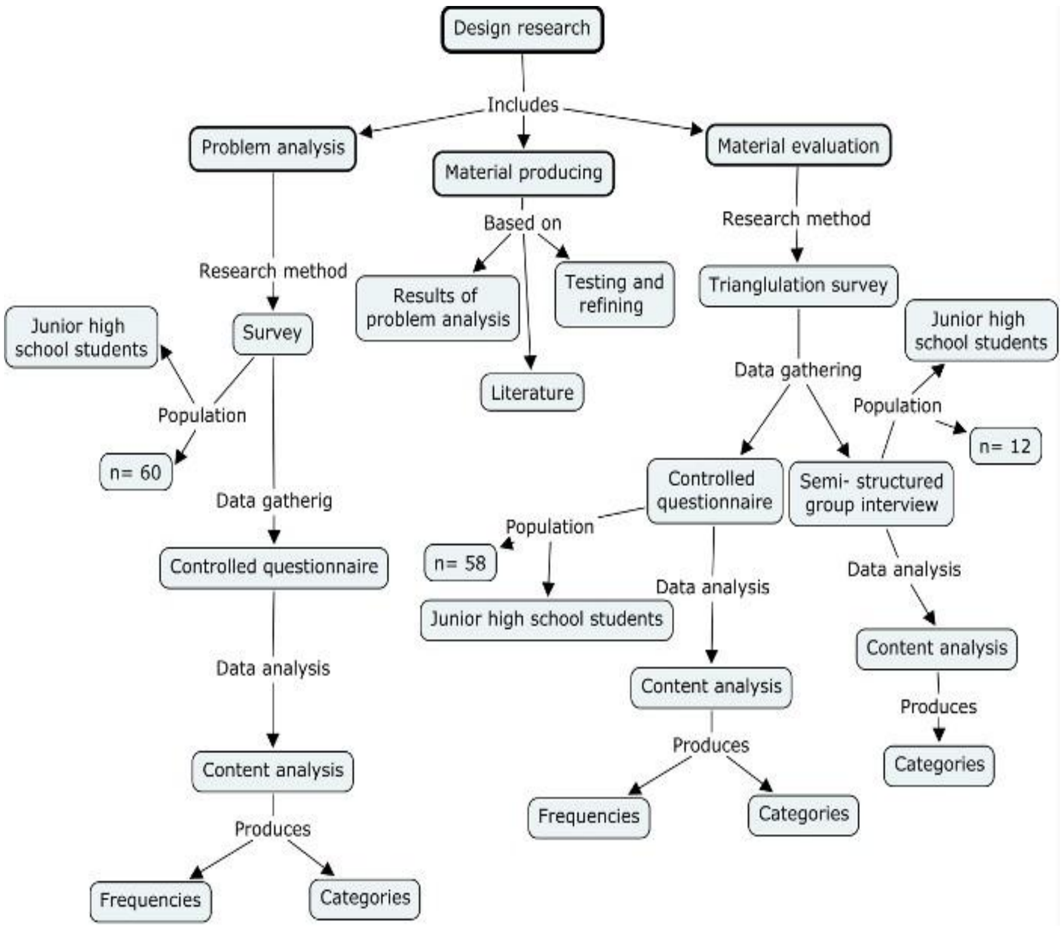

Figure 7: The research methods of this study.

A controlled questionnaire was used as a data gathering method through survey. The use of controlled questionnaire ensures a good response percent, and makes it possible to provide the respondents with instructions. The respondents can also ask for clarification if a question is not fully understood (Hirsjärvi et al., 2009). The students participated in a basic lesson about computer-based molecular modeling that is offered by the Gadolin chemistry laboratory. After the lesson, the students completed a questionnaire. The questionnaire included one closed Likert scale type of questionnaire item, and one open question. The Likert item measured the students' interest towards computer-based molecular modelling as a studying tool. The scale was from 1 to 5 (1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree). The respondents were asked to specify their level of agreement to the statement: "Computer- based molecular modeling was interesting." There was also the possibility to indicate that the respondent has no opinion on the matter (0 = I have no opinion). Especially, while studying children and young people, it is important not to assume that the respondent always has an opinion (Cohen & Manion, 2009). The open question was: "Do you think that using computer-based molecular modeling would make chemistry lessons more interesting? Please, give reasons." A pilot test was conducted before the actual test and the questionnaire was revised after the pilot test. The validity of categories formed was evaluated by another researcher in chemical education.

The responses to the closed question were analyzed quantitatively. The modes and frequencies were calculated. The open question was analyzed by content analysis method which is based on grounded theory (Cohen et al, 2009). The responses to the open question were encoded by using open code type grounded theory method.

In the second case study, the developed material was evaluated by the students. The used research methods were a semi-structured group-interview and a questionnaire. In a triangulation, two or more research methods are used to measure one object. With triangulation, it is possible to obtain deeper and more reliable results compared to the use of one research method (Cohen et al., 2009).

The students had an opportunity to ask questions, if something in the questionnaire was unclear to them. The questionnaire included three parts. There were eight Likert items on how interesting students' found the different actions in computer-based molecular modelling; one Likert item on students' interest towards modeling as a whole; and two open guestions. Students specified their level of agreement to the statements by five-level Likert scale (1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree). There was also the possibility to indicate that the respondent has no opinion on the matter (0 = "I have no opinion"). The open questions were: "What was interesting in modeling?" and "What was uninteresting in modeling?" A pilot test was conducted before the actual test, and the questionnaire was revised after the pilot test.

Randomly selected students (n = 12) participated in three semi-structured group interviews. A group interview may be a better way to canvass junior high school students' feelings and interests than a personal interview, because young people feel more encouraged to reveal their real opinions when they have the support of a group (Hirsjärvi & Hurme, 2009). The interviews were held in a quiet space with no interruptions. There were open questions about the thoughts that the modeling had invoked. The students had the opportunity to freely describe and discuss their thoughts with the group. The interviewer presented themes and encouraged the students to speak out. Also one of the Likert items from the questionnaire, the one that measured the students' interest towards the modeling as a whole was asked again. The purpose of this was to find out how similar the answers were compared to the questionnaire responses. The structure of the interview was tested and revised twice before the actual interview. The interviews were videotaped to ease the transliterating. The videotaped material was transliterated and analyzed by material-based content analysis method. The data was encoded with open-coding system. The used categories emerged from the data. The validity of categories formed was evaluated by another researcher in chemical education.

RESULTS

As a result of the first case study (a problem analysis), the students found the molecular modeling with computer interesting. The interest level was measured with a five-level Likert scale.

Students felt that using molecular modeling in schools would make studying chemistry more interesting. The mode of the answers was 4. 24 students chose the option 4 or 5. Only five of the students chose the option 1 or 2. 44 students gave reasons for their opinion. 42 of the reasons were positive and two negative. The positive reasons were divided into six categories by using content analysis. These are presented in the concept map (Figure 2). Students felt that molecular modeling was interesting because (i) it gave some variety to regular chemistry lessons, (ii) it helped to improve the understanding of chemistry, and (iii) the students themselves had an active role. Working with a computer was also highly valued.

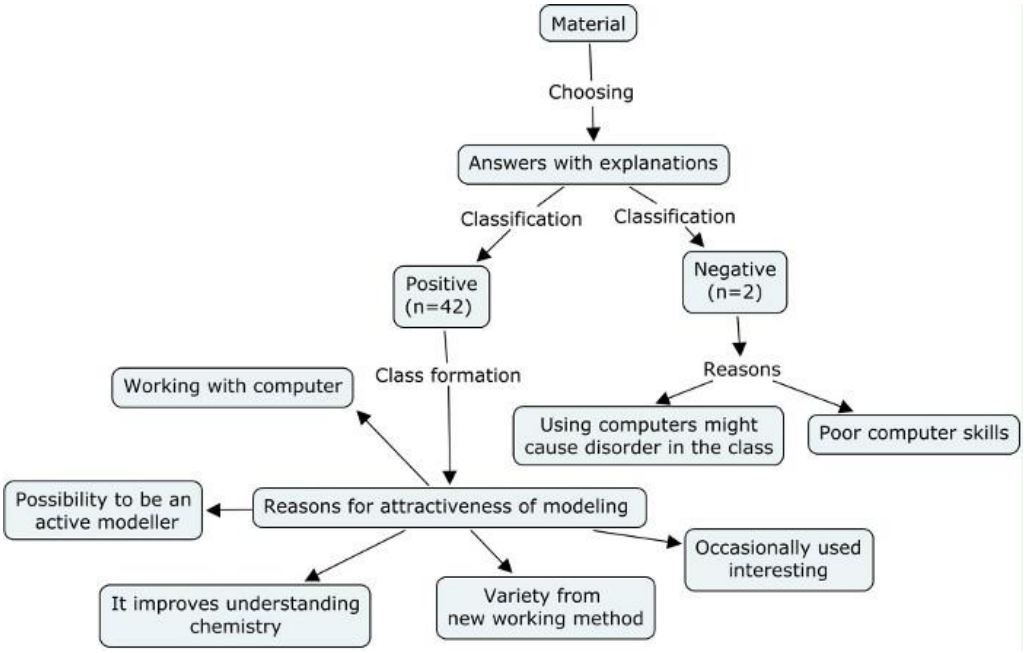

Figure 8: Concept map from the problem analysis results

The third stage of the study included two parts: an interview and a questionnaire. The responses to the questionnaire revealed that the students agreed that modeling was an interest-increasing way to study chemistry. The mode of the answers was 4. See frequencies in table 1.

The possibility to perform modeling themselves was highly valued among the students. The mode of the statement: "It was interesting to perform modeling myself" was 5, and chosen by 29 students. The students felt that the visual aids for molecular modeling increased their interest. They felt that examining molecules' three-dimensional shapes was interesting (mode 4). The students were also keen on "seeing" the molecules (mode 5), and modeling the same molecule with different models was also liked (mode 4).

The elements of molecular modeling that enable the students to examine and predict the properties of molecules were perceived to be interesting by the students. The mode of interest in explaining the molecular properties with models was 4, modeling electron densities was evaluated with mode 4, and measuring bond lengths with mode 3. Table 1 shows frequencies of answers.

Table 16: Frequencies to propositions

Proposiotion	Level of agreement 0	1	2	3	4	5	Total
It was interesting to perform modeling myself	3	2	1	5	18	29	58
It was interesting to to examine molecules' three-dimensional shapes	1	1	4	3	30	19	58
It was interesting to "see" molecules	2	3	1	13	19	20	58
It was interesting to model the same molecule with different models	1	3	3	15	24	12	58
It was interesting to explain the molecular properties with models	2	4	6	15	21	10	58
It was interesting to model electron densities	4	2	4	18	21	9	58
It was interesting to build molecules	1	2	2	9	25	19	58
It was interesting to measure bond lenghts	3	9	7	21	12	6	58

55 students answered the open question on why the molecular modeling was interesting and why it was uninteresting. The interest increasing qualities were divided into six classes. The classes are shown in table 2 with examples of the students' answers. 40 students expressed their opinion on why modeling was uninteresting, and 20 of them felt that nothing of it was uninteresting. The 20 answers were divided into five classes. Students were not keen on measuring bond properties (frequency 5), and waiting during the calculations (f. 4). Modeling was considered challenging (f. 5), and listening to the instructions was not enjoyed either (f. 3). Two students found nothing interesting at all.

Table 2: Students' opinion of the interest increasing qualities of molecular modeling

Class	F	Examples
Ability to have an active role in modeling	11	"It was fun to build molecules by myself." (Student 25) "To experience building the molecules and structures by myself" (Student 4)
Constructing molecules	14	"Most interesting was to construct molecules" (Student 21)
"Seeing" molecules	15	"To find out what a molecule looks like from different angles." (Student 29)
Explaining the properties of molecules with models	5	"To understand the relationship between molecule structure and function" (Student 53)
Enhanced understanding of chemistry	4	"Because I saw molecules and understood what was revealed in the chemistry lessons at school" (Student 45)
Wholeness	3	"Everything was interesting!" (Student 35)
Nothing	2	"Nothing was interesting" (Student 19)
n	**55**	

12 students were interviewed in three small groups. 11 students said that modeling increased their positive attitude towards chemistry. One thought that modeling was completely pointless. Students described modeling as was fun, inspiring, useful, and interesting. The feelings that the modeling invoked in the students are presented in the concept map (figure 3). 11 students were enthusiastic about the idea that modeling would be used as a tool in chemistry education. They gave reasons why modeling would bring variety to the lessons and make studying chemistry more interesting.

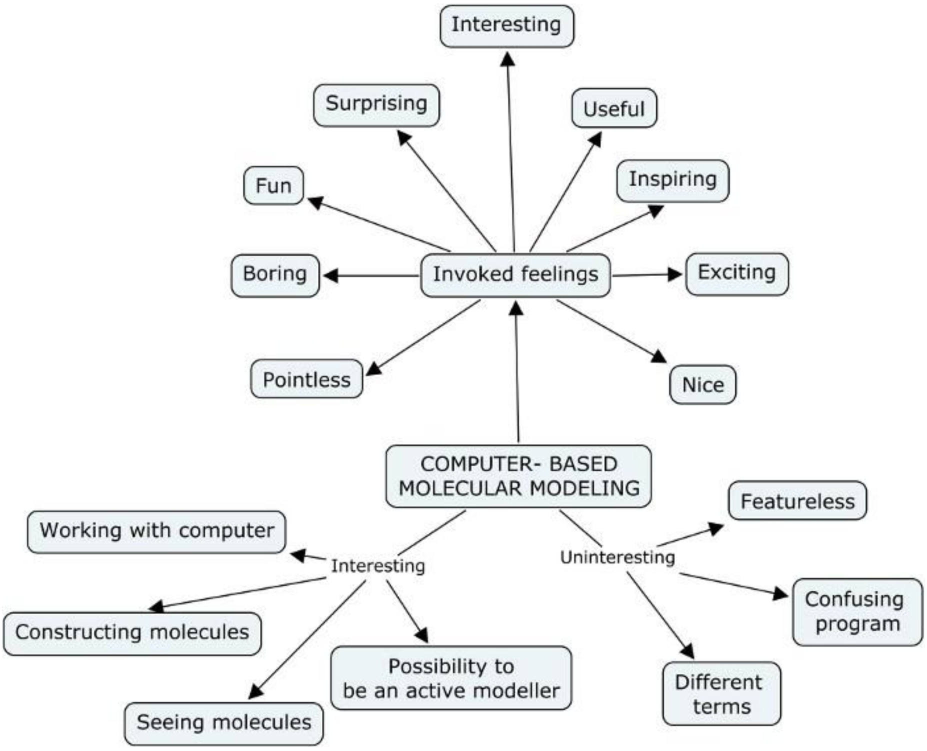

Figure 9 Students' opinions about molecular modeling

DISCUSSION

The students view computer-based molecular modeling as an inspiring way to study chemistry, and they believe that the use of molecular modeling in schools would make studying chemistry more interesting. Modeling would make lessons more versatile, and the students also felt that they would understand chemistry better if computer-based molecular modeling was used in schools. Similar results have emerged from previous researches. Jääskeläinen & Aksela (2008) found that more than half of the students found modeling with computers interesting because it brought variety to chemistry lessons. Some students felt that the interest was triggered by learning new things.

Chemistry is regarded as a difficult subject because of the invisible nature of atoms and molecules (Garnet et al., 1995). With computer-based molecular modeling, atoms and molecules can be effectively visualized to make chemical phenomena visible. As a result of this study, students found that "seeing" molecules increased their understanding of chemistry, and thus made studying chemistry more interesting.

Although the population in the problem analysis of this study was quite small (n = 60), the results strongly indicate that there is a justified need to develop computer-based molecular modeling material for chemical education in order to support interest and learning. 40 students found that molecular modeling increased their interest in chemistry. Only two students regarded modeling as uninteresting. This strong distribution is a well-justified reason to develop material that properly exploits computer-based molecular modeling in order to increase students' interest in chemistry.

As a result, material for computer-based molecular modeling was developed. Students described modeling as fun, useful, inspiring, and interesting. The possibility to perform modeling themselves was the most valued part. This result is in line with previous studies. The students become interested when they have an active role and take responsibility for their own learning (Hidi & Renninger, 2006). The visual aids were also highly appreciated. Seeing molecules was found interesting because it was a way of tangible, improved learning. In order to develop situational interest into personal interest, it is important to improve the students' knowledge, skills and self-efficacy (Hidi & Renninger, 2006; Lavonen et al., 2005). The students found that they learned chemistry better, because they were able to see molecules, and examine the molecular properties with models. Barnea & Dori (1996) studied students' attitudes towards molecular modeling, and found that students understood chemistry better via visualization. Measuring bond length was least liked, but the responses were still neutral. None of the modeling actions was found uninteresting. Many previous researches have shown that modeling is regarded as an interesting working method among students (Barnea & Dori, 1996).

The interviews supported the results from the survey analysis. The students stated that constructing molecules, and seeing them, improved learning, and invoked their interest. Triangulation as a research method improves reliability when two research methods have shown similar results to one problem.

In this study, one goal was to develop material for computer-based molecular modeling that would increase the attractiveness of chemistry. The material that was developed as a result supported students' interest in chemistry quite well. In previous research, 16% of students of the same age found modeling very interesting. The interest was measured with a five-level Likert scale (Jääskeläinen & Aksela, 2008). In this study, modeling material was developed in order to increase interest, and 38% of the students found modeling very interesting. The results are not directly comparable, but the difference indicates that the material fulfilled its goals. Most importantly, the students' interest toward chemistry increased and they gave justified reasons for it after working with computer-based molecular modeling software. They found modeling fun, but also useful for learning. When planning chemistry education, students' opinions should be heard and teachers should use working methods that students find useful and interesting. In this study, the students spontaneously emphasized that modeling improved their learning and was therefore considered interesting. As a result of this study, the development of more computer-based molecular modeling material for chemistry education is highly recommended in the future.

Needs for further studies emerged from the present study. It is necessary to study how more stable interest development could be supported with computer aided molecular modeling. It is also important to study how modeling affects the quality of learning. Students' interest and enthusiasm towards studying chemistry can be supported by including computer aided molecular modeling in chemistry education. Even though a single working method can not offer a solution to improve the attractiveness of chemistry, versatile and well-chosen working methods combined can have a tremendous influence on students' interest. Computer-based molecular modeling is one way to improve the attractiveness of chemistry among young chemistry students.

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RELATIONSHIPS BETWEEN SCHOOL SCIENCE CHOICE IN SECONDARY AND ROSE ATTITUDINAL FACTORS

Ángel Vázquez-Alonso
University of the Balearic Islands, Spain
angel.vazquez@uib.es

María Antonia Manassero-Mas
University of the Balearic Islands, Spain
ma.manassero@uib.es

ABSTRACT

This paper presents an empirical analysis about the influence of affective factors on the first choice of science school subject carried out by secondary students, across sex and education type (coeducation or single-sex education). The science attitudinal factors are extracted by means of principal component factor analysis from a wide array of variables of ROSE questionnaires (image of science, preservation of the environment, attitudes toward school science, out-of-school experiences and expectations on a future job). The data analysis involves a discriminant analysis, which contrasts the predictive power of the attitudinal factors regarding the choices (election – non election of science subject) and across three groups, sex (girls and boys) and education type (girls educated in single sex school). The results prove the predictive power of the attitudinal factors on choices, identify the significant factors for the science choice in each group and describe the differences among the groups. Its implications for school science education are discussed.

Keywords: *science education, school science, subject choice, scientific vocations, gender differences, single-sex education.*

INTRODUCTION

The crisis of scientific vocations is a general concern today in many countries, as they realize it challenges seriously the future because science and technology (forward S&T) lie in the core of the economic development in knowledge societies (Zamora, 2004). The Rocard report (Rocard, Csermely, Jorde, Lenzen, Walwerg, & Hemmo, 2007) expresses this general concern at its very beginning:

> *"In recent years, many studies have highlighted an alarming decline in young people's interest for key science studies and mathematics. Despite the numerous projects and actions that are being implemented to reverse this trend, the signs of improvement are still modest. Unless more effective action is taken, Europe's longer term capacity to innovate, and the quality of its research will also decline. Furthermore, among the population in general, the acquisition of skills that are becoming essential in all walks of life, in a society increasingly dependent on the use of knowledge, is also under increasing threat."(p. 7)*

Some years ago the European Education Council (European Council, 2003) had already addressed this challenge proposing to European Union the following benchmark to 2010:

> *"To increase at least 15% the number of graduates in mathematics, sciences and technology, reducing the imbalance in the representation of men and women."*

The European Union also summoned a monographic congress under an expressive motto "Europe needs more scientists" to study this question (Gago, 2004).

Besides, the most dramatic problem that school science education addresses today is affective: boredom, indifference and difficulty that are translated into the students' abandonment of scientific careers, when the moment of choosing studies or careers arrives (Fensham, 2004; Millar and Osborne, 1998; Pérez, 2005; Rocard, et al., 2007; Williams, Stanistreet, Spall, Float & Dickson, 2003). The youths' lack of interest toward scientific and engineering careers is a well confirmed fact (Vázquez and Manassero, 2008). Furthermore, the students who choose a science career justify it because they perceive a better labour future, but their opinions on the lack of attractiveness and difficulty of science are similar to those who made the opposite choice (Lindahl, 2003).

The research on choice identifies sex as an influential factor, whose predictive power is similar to previous school marks (Croxford, 2002). Sex is so important into professional development that careers are usually classified as masculine (sciences, engineering) and feminine (care professions, education, health, etc.). The masculine mark of S&T arises from the historical prevalence of scientists men and the lower participation of women in science, although it is also rooted in other features, as the boys' highest choice for technology, physics and chemistry and girls' for biology and health (Farenga and Joyce, 2000; Manassero and Vázquez, 2003; Stark and Gray, 1999; Vázquez, 1999).

> *"When looked at [science education] from a gender perspective the problem is even worse as, in general, girls are less interested in science education than boys. As shown by the OECD Programme for International Student Assessment (PISA) study, at 15 years old, there is already a strongly gendered pattern and in most countries females are significantly less interested in mathematics than males. This pattern of gender differences continues with women choosing fewer academic studies in math, science and technology (MST). In fact, at the European level, girls account only for 31% of MST graduates (2004)." (p. 11, Rocard, et al. 2007)*

Summing up, science has a gender bias, which produces some empirically contrasted gender differences in science education: boys exhibit better school achievement and attitudes toward school S&T than girls. The gender differences in school achievement, motivation, attitudes and out-of-school experiences related to science are favourable to men, in general, and they constitute the core of the so called andocentric bias of S&T (Jones, Howe & Rua, 2000; Vázquez, 1996, 2000).

This andocentric bias of S&T is a stereotype that arises in the school context dominated by the coeducational model (girls and boys are taught together within the classrooms). The evident differences between adolescent boys and girls, affective and cognitive abilities, learning styles, etc., learning difficulties in specific subjects (maths and science for girls, language for boys) and the uneven interactions and coexistence in coeducational classrooms contribute to harm mainly women, and affect their consequent school choices (Ainley and Daly, 2002; Salomone, 2003; Smithers and Robinson, 2006; Spielhofer, Benton and Schagen, 2004; Younger and Warrington, 2005). The boy-favourable biased stereotype on gender differences in S&T is an indicator of the inability of coeducational school to meet the differential needs of boys and girls in science classrooms. Thus, some have turned to educate girls and boys separately (SSE) as an alternative educational practice to non critical coeducation (COED).

A further gender-related issue is the educational controversy between single-sex and coeducational schooling. Although coeducation has many positive aspects, the facts accounted for in the previous paragraph also provide evidence that COED has not been effective to eliminate sex discriminations against women; the critics even claim that COED could indirectly contribute to hide and to favour discrimination (Fize, 2003). The controversy is centred in determining the educational effectiveness between SSE and COED. The advocates of the single-sex education (boys and girls are taught separately), claim that both sex groups, mainly in the adolescence, sustain different learning interests, styles and paces that are not easily concealable, and whose requirements are not appropriately met by coeducation. They argue that sex separation contributes to isolate boys or girls from the learning harmful interferences that are emitted by the other sex, so that the learning is reinforced and improved for all, boys and girls (Salomone, 2003). The single-sex education seeks to improve the coexistence, by avoiding the noxious effects of those inconvenient interactions and by better addressing the specific learning difficulties (language in boys and sciences and mathematics in girls), as a mean to eliminate the sexist discriminations in education (Younger and Warrington, 2005). Some studies even suggest that the SSE could partially break the gender stereotypic choice bias in S&T, increasing the women's election of S&T (Ainley and Daly, 2002; Spielhofer et alt, 2002), although others consider that the evidences about the superiority of SSE are still ambiguous (Smithers and Robinson, 2006).

Closing the loop, the sex also influences the students' attitudes, which includes the attitudes toward the school science, the global image of S&T, the job and vocational expectations, the interests, etc. (Vázquez & Manassero, 1995, 2007a). These affective variables also influence the academic elections and, thus they could be good explanatory variables on the subject choice (Breakwell and Beardsell, 1992; Gardner, 1975; Haste, 2004). Some additional studies address the interactions between the science election and other variables: perception of S&T and school science, the scientists' image, interaction with significant adults, depression, low science self-esteem and lack of information on scientists and S&T (Cleaves, 2005).

Nevertheless, studies on the relationship between attitudes and S&T election have been relatively scarce (Gardner, 1975; Qualter, 1993). In this framework, the elections of secondary school subjects are determined by diverse school factors, such as the pleasure on subject, the school qualifications, the perception of the personnel value and competence, the professional and academic orientation information, and other out-of school variables such as informal resources (museums, clubs, etc.), friends and peers, relatives, etc. (Blenkinsop, McCrone, Wade & Morris, 2006).

This study seeks an empirically based answer to these issues, through a reanalysis of the ROSE project database (Schreiner & Sjoberg, 2004; Vázquez & Manassero, 2007b), by considering the science election as the dependent and central variable. This study aims to empirically identify the attitudinal factors related to S&T that account for the first choice of a science subject in secondary compulsory education. It also analyzes the mediation of sex (co-educated boys and girls) and the education type (coeducation or single-sex school) on the choice. The initial hypothesis expects that these groups will display different attitudinal profiles of science election.

The school choice of eligible science subjects is the first step to a potential scientific vocation and career. Thus, these factors are expected to become core hints to innovate, improve and promote better scientific literacy and scientific vocations in the school science education among the youths both, in scientific and non scientific people.

METHOD

ROSE (Relevance of Science Education) project aims to gather and analyze evidences about the perception of young pupils, who finish their compulsory secondary school about different S&T-related issues.

Sample

The participants are 15/16 year-old students belonging to 32 public and private schools in the Balearic Islands (Spain), each school contributing with just one 10-grade group class chosen at random; four groups in the sample belong to the alone girls school. The whole sample involved 860 students who responded the ROSE questionnaire (Schreiner & Sjoberg, 2004), and are divided by sex and type of education into three groups, denominated girls, boys and alone girls.

The alone girls group involves 120 girls educated in a school only for girls, although the school staff is mixed. the group of girls (409) and boys (331) are students educated in mixed schools (COED schools). The mainstream youths are 15 (59%) and 16 (29%) years old; a majority (57%) had chosen one science subject the year of questionnaire application, although the group of alone girls shows a higher proportion (85%).

Table 1. Description of the orthogonal and not correlated factors (average zero and standard deviation unit) that arise from the factor analysis on the questionnaire items (149) for the whole sample. Each factor displays its label and a brief content description, its range (maximum and minimum), reliability, item number, and the text of the item with the highest factor load.

FACTORS	Content / first item of the factor	Minimum	Maximum	Cronbach's Alpha	N of Items
BRICOLAGE	Activities with diverse tools and machines in the daily life G68. used a car jack	-2,132	3,644	0,909	23
SCHOOL	Perception of the school science f6. I like <Science at school> better than most other subjects	-3,031	2,417	0,869	15
FARM	Farm activities (care of animals,…) g9. cared for animals on a farm	-2,502	3,498	0,848	15
TICS	Use of technologies of information and communication g56. sent or received e-mail	-3,390	2,057	0,805	7
HOME_ASTRONOMY	Home activities and basic astronomy g59. baked bread, pastry or cake	-2,634	3,043	0,707	8
MEASUREMENT	Use of simple measure apparatuses g49. used a measuring ruler, tape or stick	-3,770	2,423	0,770	6
ECOLOGISM	conservationist attitudes to the nature g19. The natural world is sacred and should be left in peace	-4,340	3,347	0,439	9
PROGRESS	Image of progress of S&T h2. Thanks to science and technology, there will be greater opportunities for future generations	-5,101	3,406	0,624	8
SOCIAL	Social image of S&T h8. Science and technology are helping the poor	-3,323	3,748	0,250	7
CREATIVE JOB	Creativity and invention in a future job b10. Making, designing or inventing something	-3,274	2,950	0,734	4
POWER_FAME	Power and fame in a future job B25. Becoming 'the boss' at my job	-3,376	3,168	0,480	5
USING_APPARATUS	Operating simple scientific apparatuses g34. used a microscope	-2,516	3,837	0,496	7
LEISURE	Value the leisure time in a future job b12. Having lots of time for my friends	-3,644	4,149	0,672	4
ECOAPATHY	Apathy before the conservation of environment d14. Environmental problems should be left to the experts	-3,896	3,649	-0,196	5
SELF_ACTUALIZATION	Upgrade and development in a future job b15. Working with something I find important and meaningful	-4,111	2,897	0,327	7
ILLNESS	Experiences of health and illness g31. taken medicines to prevent or cure illness or infection	-2,763	3,611	0,603	4
INTEREST	Dynamism and illusion in a future job g20. Working at a place where something new and exciting happens frequently	-3,612	2,814	0,652	3
RISKS	Risks in the nature because of S&T d12. It is the responsibility of the rich countries to solve the environmental problems of the world	-3,450	3,092	0,252	4
TEAM_WORKING	To collaborate with people in a future job b1. Working with people instead of things	-3,036	3,631	0,544	3

Instrument
The ROSE questionnaire has hundred of items that are merged into different thematic sub-questionnaires. The instrument of this study uses 149 items of the ROSE questionnaire (Schreiner and Sjøberg, 2004; Vázquez and Manassero, 2007a), belonging to four attitudinal scales and an inventory of out-of-school experiences.

The four attitudinal scales are labelled My future job (27 items), Me and the environmental challenges (19 items), My science classes (18 items), My opinions about science and technology (16 items). The pupils express agreement or disagreement on each item, ticking one point on a four-point Likert scale, whose categories rang from 'Disagree' (1) to 'Agree' (4).

The inventory “My out-of-school experiences” lists 69 activities related to S&T, and the students are requested on each activity to score the frequency of their practice on a 4-point Likert-type scale, ranging from never (1) to often (4).

Procedures
The dependent variable is the current choice of one science school subject that year, which is a dichotomised variable that takes two values: science (one science subject was elected by pupil), and non science (any science subject was elected by pupil). Given the dichotomised nature of the dependent variable (election of science), a discriminant analysis (DA) is applied to classify cases into the groups (science, non-science) through the attitudinal factors. The DA identifies the significant attitudinal factors that better predicts the students’ choice of school science across sex and education variables.

The independent variables (predictors of pupil’s choice) are the attitudinal variables that are drawn out from the direct scores of 149 ROSE items. This large set is reduced to a cluster of 19 normalized orthogonal attitudinal factors (average, zero; standard deviation, unit) by means of an exploratory principal component factor analysis (PCA) with a Varimax rotation (table 1).

The study uses student’s sex (girls and boys) and type of education (single-sex or coeducation) as grouping variables for the three groups described in the sample: boys (co-educated boys), girls (co-educated girls) and alone girls (girls educated in single-sex).

RESULTS

Table 2 summarize the descriptive statistic of factors for the whole sample and the three groups (boys, girls and alone girls) and the probability of significance of the differences between science and non science groups. The mean factor scores show remarkable variations along factors and between the students who have chosen science and those who have not, and among sex and education sub-groups.

Boys score much higher than the two girl groups for the Bricolage activities and score much lower for Home activities. The alone girls (single-sex education) display much higher scores than the other two groups for the School factor, TICs and Illness activities, and Self-actualization job feature, and much lower scores for the preference for Environmental jobs. The specific comparison to girls shows that the alone girls display overall higher scores than girls in most of factors, which point out an alone girls’ general attitudinal profile more favourable toward S&T; furthermore, the scores are much higher than girls in the Measurement activities, Image of Progress of S&T, and the Eco-apathy attitude. Girls display higher scores that the other two groups in the Perception of the S&T Risks.

In regard of the differences between science choosers and rejecters, for the total sample, science group has higher scores than non science counterpart in almost all factors; the only exception are Leisure and Risks factors. However, the differences are only statistically significant (p <.01) and favourable to science choosers group in four factors: attitudes toward the School science, TICs and Illness activities, and S&T Progress; nevertheless, none of that differences are relevant (effect size higher than 0.30).

Table 2. Descriptive statistics of the attitudinal factors obtained from the exploratory principal component factor analysis for the total sample and the groups defined for this study: girls (COED), boys (COED) and alone girls (girls in single-sex education).

FACTORS	TOTAL SAMPLE					GIRLS				
	Science (N = 491)		Non science (N = 369)			Science (N = 206)		Non science (N = 203)		
	Mean	S. D.	Mean	S. D.	Sign. (p)	Mean	S. D.	Mean	S. D.	Sign. (p)
BRICOLAGE	0,05	1,005	-0,066	0,991	0,0915	-0,426	0,678	-0,533	0,633	0,0986
SCHOOL	0,088	1,004	-0,117	0,984	0,003	-0,019	1,031	-0,165	1,016	0,1527
FARM	0,039	0,997	-0,052	1,003	0,1876	0,126	1,008	-0,111	0,948	0,0147
TICS	0,001	1,025	-0,002	0,967	0,9678	0,375	0,889	0,34	0,864	0,6848
HOME_ASTRONOMY	0,117	0,975	-0,155	1,013	0,0001	-0,006	0,96	-0,143	0,978	0,1553
MEASUREMENT	0,042	0,995	-0,055	1,005	0,1594	0,15	0,937	0,015	0,995	0,1591
ECOLOGISM	0,041	0,986	-0,054	1,017	0,1706	0,085	1,005	-0,012	1,024	0,3337
PROGRESS	0,083	0,982	-0,111	1,014	0,0049	0,028	0,893	-0,227	0,948	0,0052
SOCIAL	0,023	1,006	-0,03	0,992	0,442	-0,003	0,999	-0,069	0,953	0,4976
CREATIVE JOB	-0,001	1,032	0,001	0,957	0,9752	0,022	1,103	0,008	0,983	0,8848
POWER_FAME	0,052	0,989	-0,07	1,012	0,0772	-0,037	1,043	-0,175	0,952	0,1635
USING_APPARATUS	0,03	0,989	-0,04	1,015	0,3068	0,063	0,912	-0,047	0,84	0,2021
LEISURE	-0,023	0,997	0,031	1,005	0,435	-0,162	1,024	-0,146	0,92	0,8633
ECOAPATHY	0,029	0,995	-0,039	1,007	0,319	0,082	0,921	-0,022	1,044	0,2855
SELF_ACTUALIZATION	0,069	0,983	-0,092	1,017	0,0195	0,039	0,981	-0,082	1,022	0,2234
ILLNESS	0,11	1,012	-0,146	0,966	0,0002	0,03	1,022	-0,143	0,967	0,0798
INTEREST	-0,031	1,01	0,042	0,986	0,2878	0,087	0,972	0,234	0,914	0,1155
RISKS	0,064	1,006	-0,085	0,987	0,0298	0,159	1,005	-0,019	1,003	0,0745
TEAM_WORKING	0,045	0,982	-0,06	1,022	0,1297	0,064	0,944	-0,039	1,004	0,2888

Within the girls group (COED), science girls show higher scores than non science girls along all the factors, except Risks. However, the differences between science and non science girls are only significant (p <.01) and favourable to science girls for the S&T Social Impact factor, although the difference between groups is not relevant.

Within the boys group (COED), the score averages for science and non science groups are relatively homogeneous (very close to each other) and near to the null value for almost all the factors, except in the case of the Bricolage (very high) and Home (very low) activity factors. Science boys display higher scores than non science boys in most of the factors, but the differences are statistically significant (p <.01) just for TICs activities.

The factor average profile of the alone girl group differs noticeably from the profiles of the other two sub-groups (boys and girls). On the one hand, alone girls mostly show higher and more positive factor score averages than the other groups. On the other hand, science alone girls do not show a higher score profile than non science alone girls, rather the non science alone girls score higher than science alone girls in some factors. Yet, the differences between science and non science alone girls are only significant (p <.01) and relevant for two factors (Farm and Illness activities); non science alone girls show much higher score for Farm, while science alone girls score higher in Illness.

Table 2 .(cont.)

FACTORS	BOYS					ALONE GIRLS				
	Science (N = 183)		Non science (N = 148)			Science (N = 102)		Non science (N = 18)		
	Mean	S. D.	Mean	S. D.	Sign. (p)	Mean	S. D.	Mean	S. D.	Sign. (p)
BRICOLAGE	0,769	1,048	0,618	1,024	0,1901	-0,28	0,694	-0,433	0,772	0,3967
SCHOOL	0,109	0,948	-0,071	0,963	0,0889	0,265	1,027	0,053	0,769	0,4045
FARM	0,025	1,01	-0,043	1,059	0,551	-0,113	0,94	0,54	0,984	0,008
TICS	-0,625	0,88	-0,51	0,903	0,2423	0,369	0,981	0,322	0,764	0,8478
HOME_ASTRONOMY	0,105	1,068	-0,233	1,068	0,0045	0,386	0,765	0,341	0,802	0,8192
MEASUREMENT	-0,081	1,121	-0,175	1,039	0,4354	0,043	0,841	0,132	0,747	0,6758
ECOLOGISM	-0,148	0,977	-0,119	1,023	0,7927	0,289	0,901	0,008	0,912	0,2269
PROGRESS	0,088	1,076	-0,001	1,081	0,455	0,185	0,979	0,307	1,011	0,6287
SOCIAL	0,05	1,062	0,011	1,058	0,7404	0,027	0,924	0,069	0,89	0,8584
CREATIVE JOB	-0,055	0,911	-0,014	0,906	0,6793	0,05	1,093	0,054	1,115	0,9868
POWER_FAME	0,099	0,99	0,036	1,072	0,5765	0,148	0,861	0,254	1,05	0,6426
USING_APPARATUS	-0,031	1,092	-0,048	1,206	0,8937	0,073	0,945	0,106	1,143	0,8954
LEISURE	0,143	0,989	0,275	1,087	0,2496	-0,04	0,918	0,015	0,827	0,8144
ECOAPATHY	-0,109	1,058	-0,099	0,96	0,9255	0,172	0,999	0,256	0,962	0,742
SELF_ACTUALIZATION	-0,057	1,021	-0,133	1,021	0,5035	0,356	0,86	0,13	0,943	0,3141
ILLNESS	0,017	1,012	-0,145	0,973	0,1416	0,437	0,931	-0,191	0,95	0,0096
INTEREST	-0,154	1,103	-0,196	1,03	0,7246	-0,05	0,885	-0,17	0,992	0,6037
RISKS	0,025	1,028	-0,185	0,978	0,06	-0,057	0,959	-0,023	0,855	0,8885
TEAM_WORKING	-0,11	1,047	-0,118	1,057	0,9481	0,284	0,887	0,181	0,939	0,6508

The DA for the whole sample (table 3) produces six significant predictors [chi2 (6, N = 860) = 57.88, p <.0000; canonical correlation = .2558] whose predictive power is featured by the standardized coefficients values. The six significant predictors of the science election are: TICs, Illness experiences, the attitudes toward School Science, S&T image of Progress and two factors of a future job (Self-actualization and Interest).

In the group of girls, the DA produces two significant predictors [chi2 (2, N = 409) = 13.71, p = .0010; canonical correlation = .1822]. The two significant predictors (Farm activities and S&T Image of Progress) have very big positive standardized coefficients.

For boys, the DA produces two significant predictors [chi2 (2, N = 331) = 12.14, p = .0023; canonical correlation = .1906], namely TICs activities and Interest in the future job, which also display very big positive standardized coefficients.

In the alone girls group, the AD produces reversed centroids (the negative centroid for science girls) and two significant predictors [chi2 (2, N = 120) = 11.69, p = .0029; canonical correlation = .3083], namely Farm and Illness activities, which display very big standardized coefficients. The former is positive (in this case, the higher the experience in farming activities, the higher the likelihood of non choosing science), and the latter is negative (the higher the illness experience, the lower the likelihood of choosing science).

All in all, the empirical analysis on elections produces a reduced list of seven different significant factors about the decision of choosing (or not) science in secondary education. None of the seven factors is universal for all the subgroups, although some factors, as TICs, Illness, Progress and Interest repeat twice, for the total sample and at least for one of the subgroups. Farm predictor repeats for girls and alone girls, but paradoxically doing opposite roles in each group: for girls it is a positive indicator of science choice, while for alone girls indicates the opposite trend. This feature could be a cue that sound differences in science among coeducation and the girls-only education might exist.

Table 3. Significant factors and their standardized coefficients of the discriminant function obtained from the discriminant analysis for the total sample and the groups: girls (COED), boys (COED) and girls alone (girls in single-sex education).

TOTAL SAMPLE		GIRLS		BOYS		ALONE GIRLS	
Significant Factors	Coef.	Significant Factors	Coef.	Significant Factors	Coef.	Significant Factors	Coef.
SCHOOL	0,4065	FARM	0,6602	TICS	0,8456	FARM	0,6711
TICS	0,5397	PROGRESS	0,7552	INTEREST	0,5834	ILLNESS	-0,6493
PROGRESS	0,3862						
SELF_ACTUALIZATION	0,3210						
ILLNESS	0,5082						
INTEREST	0,2987						

The alone girls group achieves an outstanding landmark: it reaches a rate of correct classification of elections through DA almost total (96%) in the subgroup that chooses sciences, which is much bigger than any other rate.

DISCUSSION

This study displays through the DA the different role of the significant discriminant factors, which suggests a reflection about the differential relevance of the several attitudinal variables and their original ROSE scales from which they are drawn. In particular, the scale on the environmental future is the only one that does not produce any significant factor for the classification in none of the groups; this result is contrary to some PISA attitudinal findings, which could deserve further scrutiny. On the other hand, the inventory of out-of-school experiences (Illness, Farm and TICs), the future job features (Interest and Self-actualization) and the scale of attitudes toward School science and image of science provide the majority of the significant empirical factors.

Globally, the analyses carried out for each of the subgroups taken into account for this study (boys, girls and alone girls) show completely different discriminant predictor profiles. The comparison between girls and alone girls groups fuels the controversy between coeducation and differentiated education (single-sex), as the evidence presented here confirms different disjoint profiles for every group; at least, this break suggests that both types of education produce differential effects for science choice. Although the decision about the effectiveness of each kind of education requires deeper research, these results suggest that single-sex education (SSE) exhibits a somewhat better effectiveness inducing girls toward science, as the rate of alone girls who choose sciences is higher than co-educated girls (COED), and the same is true for the process of discriminant prediction of choice.

The implications of these findings launch a basic and evident message for science education, already underlined by others (e.g. Rocard et al., 2007): the education of key attitudinal factors must be given some priority in science teaching, according to the innovation of science education for improving learning of science and science choice. As Rocard et al. (2007) suggested:

"Recommendation 3. Specific attention should be given to raising the participation of girls in key school science subject, and to increasing their self-confidence in science." (p. 22)

ROSE (The Relevance Of Science Education) is an international project with about 40 participating countries. ROSE is organized by Svein Sjoberg and Camilla Schreiner at the University of Oslo and is supported by the Research Council of Norway. Reports and details are available at http://www.ils.uio.no/forskning/rose/

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ETHICAL ASPECTS IN SCIENCE EDUCATION RESEARCH

Janez Vogrinc

University of Ljubljana,
Faculty of Education,
Kardeljeva pl. 16, 1000
Ljubljana

janez.vogrinc@pef.uni-lj.si

Mojca Juriševič

University of Ljubljana,
Faculty of Education,
Kardeljeva pl. 16, 1000
Ljubljana

Iztok Devetak

University of Ljubljana,
Faculty of Education,
Kardeljeva pl. 16, 1000
Ljubljana

ABSTRACT

Ethical aspects are an important part of science education research. This aspect is especially important because humans are the subjects of research in the field of education. Ethical aspects of the science education research are also closely connected with the type oh research approach that the researcher choose for answering the research question(s). In the field of the humanities and social sciences, two paradigms of scientific research were developed in the past. Regarding their attributes, they are called quantitative and qualitative. Each approach has special characteristics that researcher have to follow. Ethical dilemmas that the researcher has to face are hidden in each step of the research procedure. In this paper basic ethical guidelines in conducting science education research will be presented.

Keywords: *science education research, qualitative and quantitative approaches, ethics in research.*

INTRODUCTION

Ethical aspects of research should be an important part of every researcher's work. These aspects are also important for science education researchers especially because humans are the subjects of research in the field of education. Protecting human participants in the science education research is probably the most important ethical aspect of researchers' activity, but also other ethical viewpoints regarding research procedures should not be neglected. Ethical aspects of the science education research are also closely connected with the type of research approach that the researcher chooses for answering the research question(s). In the field of the science education research (as well as in the humanities and social science), two paradigms of scientific research were developed in the past. Reflecting their attributes, they are referred to as quantitative and qualitative, respectively. In this paper, the expression "paradigm" is used in the sense of Kuhn's contemporary definition of a scientific paradigm. According to Kuhn, paradigms are "the series of reciprocally connected assumptions about social phenomena, providing the philosophical and notional frame for studying them" (Kuhn 1974, p. 39). Therefore, a paradigm is the sum of values, convictions and assumptions that, with regard to a particular scientific discipline, indicate which values, beliefs, convictions, assumptions, laws, etc., are shared by the adherents of a certain scientific paradigm, and according to which the adherents form their tradition of scientific research.

In this paper the main characteristics of qualitative and quantitative research will be analyzed and basic ethical guidelines in conducting science education research will be presented. The role of science education researcher will be explained in the framework of assuring premise for ethical quantitative and qualitative research in all phases of research process, from research planning, during conducting research, to writing research report and presenting the results and conclusions to the public.

RESEARCH APPROACHES IN EDUCATION

Quantitative research, with its empirical analytical methodology and unidirectional or linear research process, models research according to approaches following by natural sciences. The basis of quantitative research is the belief that there is a reality led by stable natural laws, independent of people and waiting to be discovered. Its objective is to reach reliable, exact, precise, measurable, verifiable, and objective observations, which in social or educational sciences would have the same value as findings in natural sciences. In quantitative research, the research problem is handled part by part. Quantitative researchers in science education approach different aspects of the phenomenon (e.g. science teaching and learning) and deal with individual variables (e.g. students' science test achievements, motivation level, mental abilities...), but on a larger number of units, most frequently on a representative sample of a population (e.g. students, teachers...), since our tendency is to generalise the established results. The use of the standardised research instruments, use of statistical methods, forming hypotheses and their reliable verification are some of the major methodological principles of the empirical-analytical methodology.

The qualitative research regarding its ontological, epistemological and methodological aspect is not a consistent phenomenon; namely, it combines different kinds of research, e.g. a case study, life history, action research and others. Bogdan and Biklen (2003) use the term »qualitative research« as the superordinate concept, joining different research approaches with certain common characteristics as well. With the expression "qualitative research" we denote that kind of research where the basic empirical material, collected in the research process, consists of verbal descriptions or narratives. Further, the collected material is worked on and analysed in words without numerical operations (Mesec, 1998). According to Creswell (1998), qualitative research is a research process designed on a clear methodological tradition of research, where researchers build a complex, holistic framework so that they analyse narratives and observations, conducting the research work in the habitat. The researcher is directly included in the environment where the data collection take place, which helps him/her to observe the object(s) of the research. In this context, the researcher should be aware of the fact that with his/her participation and the researched situation itself they influence on the phenomena that it is researched. Further, to qualitative research we also attach attributes such as phenomenological approach, the use of hermeneutical procedures of explanation, an orientation towards the process and the dynamic.

The aim of qualitative study in science education research is to gather data in the form of rich content–based descriptions of people, events, and situations by using different, especially non–structural, techniques, to discover the stakeholders' views, and to analyze the gathered data verbally, and finally to interpret the findings in a form of a concept or grounded theory which is contextually dependent. Qualitative empirical research is oriented towards examining individual cases (idiographic approach). The study is mostly conducted as a study of one case only or a smaller number of cases, therefore the techniques of data collection are adjusted to a small scale analysis, enabling the researcher to get to know the social environment. The qualitative research is carried out in line with the principles of the interpretative paradigm, i.e. the focus is on examining the subjective experiences of an individual and on recognizing the importance which the individual attaches to specific events, whereby not even the subjective views of the researcher of the studied situation are neglected. The aim is integrated and detailed cognition of phenomena, preferably in natural and concrete circumstances, for the researcher is interested in the context of the pursued activities. As part of the environment, the researcher is not only able to understand what the person is conveying in a form of a rational message and standardized speech, but also the indirect implications of this speech with a specific syntax, contextual lapses, hidden meanings and speech breaks are perceived. Wishes, expectations, interests, needs and personal opinions of the people included into the research should help the researcher to better comprehend the examined phenomena.

At data collection one is not limited to one source or one technique only. Apart from the data acquired by interviews and observation, usually also different documentary sources are used, such as personal documents (a birth certificate, an employment record, a passport, letters, photos…), different records produced in the process of data collecting, transcriptions of tape recordings, video material, etc. It is important emphasize that only the triangulation – the pluralism – of data collection techniques and their mutual combination can provide for linking the findings of individual phenomena or aspects into a meaningful integrity. Triangulation is a strategy enabling researchers to understand the observational object significantly better and in a more comprehensive manner. Multiple triangulation, assuming the combination of multiple triangulation forms, i.e. the triangulation of investigators, theories, data sources, methods and/or disciplines, provides for the exhaustive data interpretation (Denzin & Lincoln 2000; Wolcott, 1994).

At analyzing the gathered qualitative data statistical procedures are also not used, but predominantly the qualitative analysis, the essence of which is searching for codes in the analyzed materials (Bryman, 2004). The main part of the qualitative analysis of the material is formed by the coding process namely, i.e. interpreting the analyzed text and attributing the meaning (e.g., the meaning of key words, notions, codes) to its individual parts (Bryman, 2004; Charmaz 2006). Qualitative analysis of the material starts with defining the coding units, followed by the appropriate phenomena records according to our judgment and analyzing the characteristics of these phenomena, and ends with the development of the grounded theory (Glaser & Strauss, 1967). The grounded theory is read out as a narrative about the phenomenon, which was the subject of the study. It is characteristic for the theory to be constructed from the collected data and to develop in the course of the entire research process. The grounded theory is contextually bound, i.e. it is not a general theory (the findings cannot be generalized without additional definitions), but the theory of a narrower scope, valid only in certain environments and certain conditions.

It needs to be stressed that the role of the researcher and the person studied differ in the qualitative and quantitative paradigms. The quantitative paradigm typically defines the role of a person studied as mainly limited to data acquisition and the introduction of those changes established by other researchers into practice. In order to ensure the highest level of objectivity (as well as validity and reliability), a demand for separating the research object from the research subject is employed in quantitative research. This puts the researcher in charge of the research process, whereas the person studied primarily represents the source of information. It is typical for the qualitative paradigm that the researcher and those under research formulate the studied situation together.

Any research involving humans or nonhumans immediately introduces questions of ethics. Consideration of ethical issues is integral to the qualitative and quantitative research process. Researchers have two basic categories of ethical responsibility (Gravetter & Forzano, 2009): (1) responsibility to the individuals, who participate in their research studies (protecting human subjects in the process of research so that no harm is made); and (2) responsibility to the discipline (e.g. natural sciences, humanities, social sciences, educational sciences – science education) to be accurate and honest in the selecting the sample and method to answer to the research question(s) and in the reporting of research results.

ETHICS IN SCIENCE EDUCATION RESEARCH

Ethics is a branch of moral philosophy dealing with the criteria by which behavior should be judged as morally good or bad, and the standards by which behavior ought to be regulated. Code of ethics for research is issued as guidance for the proper moral conduct of researchers (Gomm, 2009). Ethics can be conceived to consist of several areas (Kitchener, 2000; Kitchener & Kitchener, 2009). (1) Descriptive ethics studies how people actually behave and what ethical values they actually hold. This area belongs to empirical science. (2) Normative ethics is concerned with the questions: How should an individual behave; what properties are valuable or good? (3) Meta-ethics asks questions about the meaning of ethical words, the logic of justifying moral decisions, the reality of moral properties, and so forth. (4) Finally, applied ethics uses principles and insights from normative ethics to resolve specific moral issues in concrete and particular settings. Science research ethics is thus an example of applied ethics.

Ethical point of view is an important component of everyday live, and we should also be aware of its importance in designing and conducting science education research. Ethics should be considered not only in the research design but also in the relation to the research participants and researchers. When the researcher is directly involved in the research procedure, especially in the qualitative research design, the relationship between the researchers and participants in the research, could be very demanding for both parts (Cencič, 2002).

HISTORICAL HIGHLIGHTS OF ETHICAL ISSUES

Until the end of World War II, researchers established their own ethical standards and safeguards for human participants in their research. It was assumed that researchers, bounded by their own moral compasses, would protect their participants from harm. The major impetus for a shift from individualized ethics to more formalized ethical guidelines was the uncovering of the brutal experiments performed on prisoners in Nazi concentration camps. A variety of sadistic ˝medical experiments˝ were conducted on unwilling participants. When these atrocities came to light, some of those responsible were tried for their crimes at Nuremberg in 1947. Out of these trials came the Nuremberg Code, a set of 10 guidelines for the ethical treatment of human participants in research (Gravetter & Forzano, 2009). The Nuremberg Code laid the groundwork for the ethical standards that are in place today. A similar set of ethical guidelines was published in 1978 when the National Commission published The Belmont Report: Ethical Principles and Guideline for the Protection of Human Subjects of Research. The Belmont Report Commission considered three principles derived from ethical considerations that should frame researchers´ efforts (Gravetter & Forzano, 2009): (1) beneficence, or the maximization of ˝good outcomes for science, humanity and the individual research participants˝ while risk to human subjects, harm, or outright wrong were to be minimized; (2) respect, by which they meant treating human participants with respect, dignity, courtesy, and agency; and (3) justice, or ˝ensuring ... those who bear the risk (as research participants) are (those) who benefit from it,˝ as well as ensuring that the procedures are ˝reasonable, nonexploitative, and carefully considered˝ as well as ˝fairly administered˝. Furthermore, the Belmont Commission spelled out six norms of scientific research (Lincoln, 2009) that should act as guidelines for the conduct of research, including: (1) the use of a valid research design, as free of flaws as possible to make it; (2) a researcher competent to conduct the research; (3) the identification of the consequences of the research, principally for research participants; (4) the appropriate use of sample selection; (5) the assurance of voluntary informed consent, and (6) information to research participants as to whether harm will be compensated.

In general, ethical issues have arisen around four major frameworks (Lincoln, 2009): (1) the ethical treatment of those with whom, on whom, and for whom (on whose behalf) we conduct research; (2) ethical considerations of the contexts in which research is conducted; (3) ethical considerations for a globalized ethnographic practice; and (4) ethical considerations surrounding data and the preparation of reports, especially in the question of for whom reports are created.

Ethical decision making is intimately intertwined with all phases of the research process. Beginning with the identification of a research topic, continuing with the choice of methods for studying that topic, and proceeding through each and every aspect of data collection, analysis, presentation, and reanalysis, decisions made feed back into theory development and influence subsequent rounds of research problem identification. Each stage of the research process shares some common ethical issues while, at the same time, each study, qualitative or quantitative, basic or applied is unique.

ETHICAL ISSUES AND HUMAN PARTICIPANTS IN SCIENCE EDUCATION RESEARCH

As we work with individual participants, we need to respect them individually, such as by not stereotyping them, using their language and names, and following guidelines such as those found in the Publication Manual of the American Psychological Association (APA, 2001) for nondiscriminatory language. The researcher has no right to harm the participants or subjects, physically, emotionally, or psychologically. On the contrary, the researcher has a responsibility to ensure the safety and the dignity of the participants.

Four protections need to be provided when conducting research with human participants (Lincoln, 2009): (1) participants should be fully informed regarding the nature of the research and the potential consequences of participating, known as informed consent, including the right to withdraw from the study at any time prior to publication; (2) deception, when it occurs as a part of the research design, must be accompanied by a full debriefing at the end of the study, to include all participants who have been duped or otherwise deceived; (3) participants must be guaranteed that they will not be identified by name or otherwise, referred to as anonymity or confidentiality; and (4) personal records will not be opened without the express consent of research participants, frequently referred to rights to privacy.

The general concept of informed consent is that human participants should be given complete information about the research and their roles in it before agreeing to participate. They should understand the information and then voluntarily decide whether or not to participate. But simply telling participants about the research does not necessarily mean they are informed, especially in situations where the participants may not be competent enough to understand. This problem occurs routinely with special populations such as young children, and developmentally disabled people. In these situations, it is customary to provide information to the participants as well as to a parent or guardian who also must approve of the participation.

Often, it is impossible to provide participants with complete information about a research prior to their participation. For example, if participants know the true purpose of a research study, they may modify their natural behaviors. To avoid this problem, researchers sometimes will not tell participants the true purpose of the study. One technique is to use passive deception, or omission, and simply withhold information about the study. Another possibility is to use active deception, or commission, and deliberately present false or misleading information (Gravetter & Forzano, 2009). In these situations, a researcher has a special responsibility to safeguard the participants and he must debrief the participants by providing a complete explanation as soon as possible after participation in completed.

In most quantitative research reports, the results are presented as average values that have been collapsed across a large group of individual participants, and there is no mention of any individual participants, code numbers, or code names. In qualitative research it is very often the case that researchers want to hide the identity of their research participants by using pseudonyms to mask particular biographical features or other obvious identifiers. While in principle this can work, there are frequently occasions where the ways that people speak, the topics that they discuss, the sorts of stories that they tell – all of these things can make the participants identifiable by other people (particularly in small samples or in tightly-knit communities). Further, it can be difficult for researchers to know which features of the data would be recognizable by others. It may be that one of the anecdotes told in an interview is widely associated with a given person (who has told it on other occasions to other people) and by using and citing it as data, the researcher inadvertently reveals the identity of the person who provided it (for more information see Gibson & Brown, 2009). In short, it is easy to promise anonymity, but in practice it can be much harder to safeguard.

The protection of data is a key issue in research. The nature of research work, and the fact, working in more than one place, and often requires researchers to share their data (in part or in the whole) with other people (e.g. by presenting at conferences, discussing with colleagues or supervisors, or working in research teams), all mean that the location of data can be hard to specify and contain. Researchers can discuss confidential information only for appropriate scientific or professional purposes, and only with persons clearly concerned with such matters; they may disclose confidential information with the appropriate consent of the individual or another legally authorized person on behalf of the participant, unless prohibited by law. Very careful thought needs to be given to how data is stored and distributed, and the mechanisms that are used to contain it within the bounds of the researcher´s control. It is also very important to think about what happens to data after a project has finished. A common approach is to assume that the best policy is to simply destroy data once the research is complete. But it is not always obvious that the destruction of data is necessarily the best option. A researcher may have an interest in preserving data so that they can show how they reached their conclusions, or in order to revisit their analysis later in order to clarify or develop it. Even research participants may have an interest in having access to such analysis so that they can trace their presence within an analysis.

CONCLUSION

In making decisions about the science education research process, it is, as for all research involving human subjects, vital to consider the ethical dimensions of the approach to be taken and the specific ethical issues that might be raised in working through a project. The general issues that need to be thought are: informed consent, confidentiality, avoiding harm, integrity and professionalism. In research, ethical issues must be considered at each step in the research process. Ethical principles dictate: (1) what measurement techniques may be used for certain individuals and certain behaviors, (2) how researchers select individuals to participate in studies, (3) which research approach may be used with certain population, (4) how studies may be carried out with individuals, (5) how data are analyzed, and (6) how results are reported.

Although the final responsibility for the protection of human participants rests with the researcher, most human-participants research must be reviewed and approved by a group of individuals not directly affiliated with the specific research study. Each institution or agency is required to establish a committee called an Institutional Review Board, which is composed of both scientists and nonscientists, and examines all proposed research involving human participants with respect to some basic criteria (e.g. minimization of risk to participants, informed consent, documentation of informed consent, data monitoring, privacy and confidentiality ...). The Institutional Review Board can require a research proposal to be modified to meet its criteria before the research is approved.

Various professional bodies provide ethical guidelines for researchers to follow in the design and conduct of their research. ˝Ethical guidelines comprise statements of intent and appropriate practice that can be used to help researchers to work through the ethical dimensions of their research˝ (Gibson & Brown, 2009, p. 60). Awareness of and affiliation to such guidelines has become standard practice. Such guidelines have the general aim of protecting the research participants and other interested parties to the research, including the researcher, as well as helping to maintain professional research standards, promote public confidence in research, and minimize legal risk.

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INVESTIGATING PRESERVES PRIMARY AND EARLY CHILDHOOD EDUCATION TEACHERS' VIEWS ON SCIENCE TECHNOLOGY AND SOCIETY ISSUES

Zeha Yakar

Pamukkale University

zehayakar@gmail.com

Ebru Ersay Cekmecelioglu

Gazi University

e3ersay@gmail.com

ABSTRACT

One goal of science education is to endorse scientific literacy for all people with a complete understanding of the nature of science and technology, and their interdependence with the society. This study explores the Turkish preserves primary school teachers' (n=52) and preserves early childhood teachers' views (n = 56) on STS issues. Data were collected through an adopted 26-items "Views on Science–Technology–Society" instrument. The analysis revealed that preserves teachers often confuse the definition of technology with science and they have varied views about the influences of society on science. According to most of the participants, the reason of doing scientific research in their country is, for example, to be independent from other countries and to get financial profit. In addition, preserves science teachers claimed that technological developments can be controlled by citizens. The results indicated that high percentage of participants from two groups was aware of tentative nature of science.

Keywords: Science–Technology–Society*, Preserves Teachers, Teacher Education*

INTRODUCTION

Science helps address issues that are of concern to the general population. Because of this reason, it is important to the public. Scientific principles have been and continue to be applied to address issues, concerns, and problems that people face in the day-to-day aspects of living. Scientific research has value and importance to person to the extent that it helps address problems of a practical nature. How science is taught and learned can determine its significance to the majority of students, not only to those planning careers in scientific fields.

According to American Association for the Advancement of Science (2001), one goal of science education is to endorse scientific literacy for all people with a complete understanding of the nature of science and technology, and their interdependence with the society. The aims of science education have been changed from pointing out cognition to ways of acquiring knowledge (Mansour, 2009). Some research indicate that college students have many misconceptions about the real world and they seem to keep these views even after completing and succeeding in advance courses dealing with scientific concepts and theories. To internalize interpretations of the real world, they need to have real experiences (Yager, 1996).

National Science Teachers Association (NSTA, 1990) views STS as the teaching and learning of science in the context of human experience. STS can be described as a student-centered teaching approach which has characteristics needed to reform effort that concerns goals, curriculum, instruction, and assessment. Science Technology Society (STS) program is to provide a real-world connection for the student between the classroom and society. The process should give the student practice in recognizing potential problems, gathering data about the problem, considering alternative solutions, and considering the consequences based on a particular decisions (Yager,1990).

It has been argued that to empower the students as citizens, there is a need to emphasize STS (Kolstoe, 2001). The National Science Teachers Association described STS as the central goal for science education in 1980s:

> The goal of science education during the 1980s is to develop scientifically literate individuals who understand how science, technology, and society influence one another and who are able to use their knowledge in their everyday decision-making. The scientifically literate person has a substantial knowledge base of facts, concepts, conceptual networks, and process skills which enable the individual to learn logically. This individual both appreciates the value of science and technology in society and understands their limitations. (as cited in Yager, 1996, p.4)

How science is taught and learned can determine the ways of people thought about the relationship among science, technology, and society.

This study had multiple purposes. First aim was illuminating and comparing preserves teachers' views, who enrolled different programs, on the STS issues in Turkey. Another purpose was to document the preserves teachers' views on the STS issues before and after taking a science education course. Although these preserves teachers will teach science to children, they were not from science education programs.

METHODOLOGY

Participants

For this study, we collected data from 108 preserves teachers. All of them volunteered to participate in the study. Fifty-two enrolled in science teaching course at Primary School Teacher Education Program and fifty-six enrolled in science education course at Early Childhood Teacher Education Program. The purpose of the courses provided for preserves teachers in this study was to provide meaningful and practical learning experiences that prepare students to create effective science learning environments for elementary school students or children in early childhood period . The course created an environment where the preserves teachers were active participants in both discussions and hands-on science activities rather than passive receivers of information.

Instrument

The Views of Science-Technology-Society (VOSTS) instrument was composed of 114 multiple-choice items that addressed a broad range of STS topics (Aikenhead, Ryan and Fleming, 1989). In this study, 26 "Views on Science-Technology- Society items" selected and translated into Turkish by Kahyaoğlu (2004) were used. Test reliability was calculated using the split half technique by correlating the odd-numbered item results with even-numbered item results. The test reliability coefficient was found to be 0.71 (Kahyaoglu, 2004). The instrument includes seven subscales. These subscales and the item numbers belonging to each scale were: (a) science and technology (three items), (b) influence of society on science/technology (four items), (c) influence of science/technology on society (five items), (d) characteristics of scientists (two items), (e) social construction of scientific knowledge (four items), (f) social construction of technology (two items), and (g) nature of scientific knowledge (six items).

One example item from VOSTS is given as follows:

10111. Defining science is difficult because science is complex and does many things. But mainly science is:
Your position, basically:
A. a study of fields such as biology, chemistry and physics.
B. a body of knowledge, such as principles, laws and theories, which explain the world around us (matter, energy and life).
C. exploring the unknown and discovering new things about our world and universe and how they work.
D. carrying out experiments to solve problems of interest about the world around us.
E. inventing or designing things (for example, artificial hearts, computer, space vehicles).
F. finding and using knowledge to make this world a better place to live in (for example, curing diseases, solving pollution and improving agriculture).
G. an organization of people (called scientists) who have ideas and techniques for discovering new knowledge.
H. No one can define science (Aikenhead et al., 1989)

Data Collection and Analysis

The adapted VOSTS questionnaire was administered to the participants as pre- and post-test in Spring 2009. The data were analyzed the frequency distribution for each item to characterize the trends in participants' perceptions of the science, technology, and society issues.

RESULTS

Results are organized under the titles of subscales. Due to the limitation of space, selected results are discussed in detail.

*Science and Technology.*The adopted VOSTS survey included three items for the science and technology subscale. The results of Science and Technology' subscales were given in Table 1.

The first item of this scale refers to the science definition. The data stated that there is no consensus on the definition of science among preserves primary school teachers (PPST) and preserves early childhood teachers (PECT). While 27% of preserves primary school teachers (PPST) define science as a body of knowledge on pre-teset, 37% of them define science as a body of knowledge on post test. On the other hand, the highest portion of preserves early childhood teachers (PECT) (pretest: 45%, posttest: 46%) define science as improving the world.

The second item of this scale is about preserves teachers' definition of technology. On pretest, 29% of PPST thought technology as the application of science. After post test, this value increased to 35%. In contrast, 29% PECT thought technology as new process, instruments, tools, machinery etc. or practical devices.

The third item assessed participants' views on issues concerning the interdependence of science and technology. On pre and post test, the highest percentage of PPST (64%) and PECT (88%) thought science and technology closely related because scientific research leads to practical applications in technology, and technological developments increase the ability to do scientific research.

Table 1: Summary of the Results of Science and Technology Subscale

		Preserves Primary School Teachers		Preserves Early Childhood Teachers	
		Pre-test	Post-test	Pre-test	Post-test
Science and Technology	1.Defining science	C %35 B %27 F %19	B %37 C %25 F %25	F %45 C %34 B %14	F %46 C %34 B %11
	2.Defining technology	C %35 B %29 G %17	B %35 G %25 C %21	B %27 G %25 C %23	C %29 B %27 G %23
	3.Interdependence of science and technology	B %79 A %12 C %6	B %64 A %27 C %6	B %84 A %13	B %88 A %9

*Influence of Society on Science and Technology. T*his subscale was composed of four items. The highest portion of PPST (42%) and PECT (52%) reported that there is need for their country to finance science in order to make their world a better place to live in, on pre and post test (Table 2).

The analysis of second item revealed that the highest portion of PPST (33%) and PECT (32%) thought the ethical and religious views are effective on how and what scientists think. They believe that scientists unconsciously choose research topics that support their cultural views.

An interesting finding emerged from the item six. On post test, while 33% of PPST claimed that the more students learn about science and technology; the more the informed the future public will be, the high proportion (48%) of PECT reported the public will better understand the views of experts and will provide the needed support for science and technology on pre and post test.

Another important result of this subscale that 33% of PPST claimed that the encouragement and opportunity to become a scientist is given by schools, family, and community on pretest. This portion decreased to 17% on post test. Even though the highest portion of PECT thought same way with PPST on pre and post test (pretest: 41%, posttest: 32%), it is possible to see decreasing on post test.

Table 2: Summary of the Results of Influence of Society on Science and Technology Subscale

		Preserves Primary School Teachers		Preserves Early Childhood Teachers	
		Pre-test	Post-test	Pre-test	Post-test
Influence of society on science/ technology	4. Government	D %40 A %33 C %15	D %42 A %29 C %15	D %43 A %27 C %21	D %52 C %27 A %16
	5. Ethics	B %23 G %19 F %17	B %33 F %31 E %12	B %27 D %18 G %18	B %32 E %21 F,G%14
	6. Education institutions	D %37 C %25 A %21	C %33 A %27 B %19	D %45 C %39 A %11	D %48 C %29 B %89
	7. Public influence on scientists	E %33 B %31 D %19	D %27 B %25 E %17	E %41 D %21 F %20	E %32 D %29 B %21

Influence of Science/Technology on Society. This subscale composed of five items. According to results on pre and post test of first item for this subscale, the highest percentage of PPST (pretest: 54%, post test: 67%) and PECT (pretest: 63%, post test: 59%) believed that scientist are concerned with all the effects of their experiments because the goal of science is to make our world a better place to live in (Table 3).

Another result of this subscale is that the highest portion of PPST (pretest: 33%, post test: 29%) and PECT (pretest: 39%, post test: 45%) believed that scientist and engineers should decide because they have the trainings and facts but the public should be involved-either informed or consulted. Almost half of the PPST (pretest: 46%, posttest: 48%) claimed that scientists are better at solving any practical problem.

According to them, their logical problem solving minds or specialized knowledge gives them an advantage. However, the big proportion of PECT (pretest: 61%, posttest: 54%) suggested that scientists are no better than the others, because in everyday life scientists are like everyone else and experience and common sense will solve everyday practical problems.

According to results of fourth item for this subscale, the highest percentage of PPST (pretest: 42%, post test: 58%) and PECT (pretest: 57%, post test: 55%) believed that scientific and technological developments make Turkey less dependent to other countries.

In the last item of this subscale, 31% of PPST on pretest claimed that the more advanced the country's science and technology, the richer that country will be. This portion decreased to 19% on post test. On the post test, 48% of PPST responded as science and technology develop in a country, more modern, accurate, and destructive weapons are built. Even though the highest portion of PECT thought same way with PPST on pre and post test (pretest: 41%, posttest: 30%), it is possible to see decreasing on post test.

Table 3: Summary of the Results of Influence of Science/Technology on Society Subscale

		Preserves Primary School Teachers		Preserves Early Childhood Teachers	
		Pre-test	Post-test	Pre-test	Post-test
Influence of science/ technology on society	8. Social responsibility of scientists/ technologists	C %54 E %15 D %12	C %67 E %8 D %6	C %63 D %13 E %13	C %59 B %13 D %13
	9. Contribution to social decisions	D %35 C %33 B %12	C %29 D %29 B %19	C %39 D %36 A,B %7	C %45 D %45 A %5
	10. Resolution of social and practical problems	A %46 D %31 E %14	A %48 D %25 B,E %10	D %61 A %29 E %5	D %54 A %34 C,G %4
	11. Contribution to economic well-being	B %42 A %35 D %10	B %58 A %25 D %12	B %57 A %30 D %5	B %55 A %25 D %11
	12. Contribution to military power	C %31 A %29 B %15	A %48 C %19 B %17	A %41 D %23 C %13	A %30 D 18 B 14

Characteristics of Scientists. There were two items under the characteristics of scientists subscale.

According to results on pretest and post test of first item for this subscale, the highest portion of PPST (pretest: 44%, posttest: 42%) and 39% of PECT on post test believed that the best scientists display some characteristics such as very open-minded logical, unbiased, and objective in their work since they improve the ability of science (See Table 4).

Another result of this subscale is that the highest percentage of PPST (pretest: 46%, post test: 42%) and PECT (pretest: 59%, post test: 50%) believed that there are no difference depending on the sex with respect to the process and product of science and they thought the source of the differences in the discoveries as the differences between individuals.

Table 4: Summary of the Results of Characteristics of Scientists Subscale

		Preserves Primary School Teachers		Preserves Early Childhood Teachers	
		Pre-test	Post-test	Pre-test	Post-test
Characteristics of scientists	13. Standards/ values that guides scientists at work and home	B %44 C %19 D %14	B %42 C %35 A %12	C %45 B %25 E %16	B %39 C %38 E %13
	14. Gender effect on the process and product of science	G %46 H %17 B %8	G %42 H %15 D %12	G %59 B %11 H %9	G %50 H %23 E %11

Social Construction of Scientific Knowledge. There were four items in this subscale.
According to results on pre and post test of first item for this subscale, the highest percentage of PPST (pretest: 50%, post test: 42%) and PECT (pretest: 38%, post test: 45%) believed that scientist publish their discoveries because this publication as both to benefit personally from any credit, fame or fortune that a discovery may bring; and to advance science and technology by sharing ideas publicly, and thus building upon each other's work (See Table 5).

Another result about second item for this subscale, the highest portion of PPST (pretest: 25%, posttest: 37%) and 34% of PECT on post test thought that science is no different from other professions in terms of the rule breaking.

The other result stated that on pretest 37% and on posttest 42% of the PPST believed that scientist can be helped by the ideas, experiences, or enthusiasm of people with whom they socialize. On the other hand, while 39% of PECT believed same thing with PPST, this portion decreased to 29% on post test.

According to results on pre and post test of fourth item for this subscale, the highest percentage of PPST (pretest: 31%, post test: 31%) and PECT (pretest: 29%, post test: 30%) believed that country makes a difference in the scientific research because of the reason as the education and the culture.

Table 5: Summary of the Results of Social Construction of Scientific Knowledge Subscale

		Preserves Primary School Teachers		Preserves Early Childhood Teachers	
		Pre-test	Post-test	Pre-test	Post-test
Social construction of scientific knowledge	15. Professional communication among scientists	B %50 C %19 A %12	B %42 C %27 E,F %8	B %38 C %29 F,G %9	B %45 C %29 F,G %9
	16. Professional interaction in the face of competition	D %25 B %21 E %17	D %37 B %27 A,E%12	B %38 E %18 A,D%14	D %34 B %21 E %18
	17. Social interactions	A %37 C %21 E %19	A %42 D %19 E %19	A %39 C %23 D %18	C %30 A %29 D %21
	18. National influence on scientific knowledge and technique	A %31 D %25 B %21	A %31 B %23 F %17	A %29 D %29 B %23	A %30 B %30 D %14

Social Construction of Technology. There were two different items in this subscale. Table six shows the results of Social Construction of Technology subscale.

More than half of the PPST (pretest: 62%, posttest: 79%) and more than half (pretest: 84, posttest: 88%) of the PECT related the decision to use a new technology with several things such as its cost, efficiency, usefulness to society, and effect on employment.

According to results on post test of second item for this subscale, the highest percentage of PPST (post test: 29%) and PECT (pretest: 36%, post test: 30%) gave the reason as the needs of consumer. It is the results of the relation between demands and profits.

Table 6: Summary of the Results of Social Construction of Technology Subscale

		Preserves Primary School Teachers		Preserves Early Childhood Teachers	
		Pre-test	Post-test	Pre-test	Post-test
Social construction of technology	19. Technological decisions	B %62 E %14 A %12	B %79 A %8 D %6	B %84 D %7	B %88 D,G,H %4
	20. Autonomous technology	F %27 C %23 D %23	C %29 A %23 D %19	C %36 D %34 A 11	C %30 D %29 A,F%16

Nature of Scientific Knowledge. There were six items on Nature of Scientific Knowledge subscale.

According to first item results of this subscale, while 37% of the PPST on pretest said that scientists will experiment in different ways and will notice different things, the highest portion of PECT (41%) claimed same thing on post-test. On the other hand, while the highest portion of the PPST (31%) on post test claimed that scientists' thinking way affects their observation, the highest portion of PECT (39%) claimed the same thing on pretest (See Table 7).

Most of the participants stated that scientific knowledge may change in the future when the investigations are done correctly. More than half of the PPST (pretest: 58%, posttest: 58%) and more than half (pretest: 57%, posttest: 70%) of the PECT claimed that by using new techniques or improved instruments, new scientists disprove the old theories or discoveries.

According to results of third item of this subscale, more than half of the PPST (pretest: 67%, posttest: 58%) and more than half (pretest: 82%, posttest: 71%) of the PECT thought hypothesis tested by experiments, if it proves correct, it becomes a theory and after a theory has been proven true many times by different people and has been around for a long time, it becomes a law.

Another result stated that the highest portion of PPST (pretest: 21%, post test: 25%) and PECT (pretest: 32%, post test: 38%) defined the scientific method as questioning, hypothesizing, collecting data and concluding. The other result of this subscale is that most of the participants said that the facts do not necessarily mean that asbestos causes cancer. The highest portion of PPST (pretest: 33%, post test: 31%) thought more research is needed to find out whether it is asbestos or some other substances that causes the lung cancer.

On the other hand, the highest portion of PECT (pretest: 48%, post test: 70%) thought asbestos might work in combination with other things, or may work indirectly. The results of sixth item for this subscale stated that the highest portion of PPST (pretest: 50%, post test: 56%) and PECT (pretest: 46%, post test: 55%) believed that one scientific idea can be interpreted differently, because they thought that the interpretation depends on the individual scientist's point of view or on what the scientist already know.

Table 7: Summary of the Results of Nature of Scientific Knowledge Subscale

		Preserves Primary School Teachers		Preserves Early Childhood Teachers	
		Pre-test	Post-test	Pre-test	Post-test
Nature of scientific knowledge	21. Nature of observations	B %37 A %25 C %17	A %31 C %29 B %25	A %39 B %32 C %18	B %41 A %29 C %18
	22. Tentativeness of scientific knowledge	A %58 B %37	A %58 B %33 D %6	A %57 D %16 B %14	A %70 B %21 C %5
	23. Hypothesis, theories and laws	A %67 B %8 C,G %8	A %58 B %29	A %82 B %9	A %71 B %29 G %5
	24. Scientific approach to investigations	G %21 E %19 D %14	G %25 A %15 C %15	G %32 I %16 A,H %13	G %38 I %18 H %14
	25. Logical reasoning	B %33 C %31 D %12	B %31 C %31 A,D,G% 12	C %48 B %30 D %11	C %70 B %20 D %7
	26. Paradigms vs. coherence of concepts across disciplines	B %50 A %21 C,E %10	B %56 A %17 E %12	B %46 A %27 C %7	B %55 C %14 A %13

CONCLUSION

This study gives insight about the views of preserves primary school and preserves early childhood teachers on STS.According to the results of this study pre-service teachers did not acquire a uniform view of science. Although many of the preserves primary school teachers defined science as content or process, preserves early childhood teachers thought it as something to make world a better place to live in. According to this study, most of the preserves teachers agreed on the effects of social contacts on the discoveries but only fifteen percent of the participants rejected the effects of social contacts which is similar to the traditional belief of objectivity of science. Participants mostly indicated the effects of different countries to the ways of looking at a scientific problem. One of the most important results of the present study is that high percentage of participants from two groups was aware of tentative nature of science.

The main purpose of science teaching course is to train scientifically literate person for a developing society. One of the important dimensions of scientific literacy is Science-Technology-Society (STS). For this reason, not just only science teachers but also all teachers must posses contemporary views about STS.

We argue that teacher training programs should be revised to improve preserves teachers' understanding of science-technology-society issues and the way that how this knowledge can be introduced to the students from any levels of education. These programs must give place to courses on philosophy and history of science.

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A CURRICULUM DESIGN FRAMEWORK FOR LINKING SIMULATION USE TO PRACTICAL WORK: TOWARD UNDERSTANDING AND FEELING A SENSE OF REALITY IN THE LEARNING ABOUT COMPLEX SYSTEMS IN NATURE

Etsuji Yamaguchi
Kobe University
etuji@opal.kobe-u.ac.jp

Akiko Deguchi
Utsunomiya University
deguchia@cc.utsunomiya-u.ac.jp

Shigenori Inagaki
Kobe University
inagakis@kobe-u.ac.jp

Sugimoto Masanori
University of Tokyo
sugi@itl.t.u-tokyo.ac.jp

Fusako Kusunoki
Tama Art University
kusunoki@tamabi.ac.jp

Yoshiaki Takeda
Kobe University
takedayo@kobe-u.ac.jp

Shinichi Kamiyama
Sumiyoshi Elementary School attached to Kobe University
s-kamiyama@people.kobe-u.ac.jp

ABSTRACT

It has been pointed out that the use of simulation poses a problem relating to the sense of reality. However, few studies have focused on curriculum design. The present research proposed “component mapping of simulation and practical work,” a new framework of curriculum design. The research featured a experiment in which elementary school students learned vegetation succession, a large temporal scale and complex system in nature, through simulation and outdoor observation. Through analyzing results of examinations and questionnaires, it was cleared the students were able not only to understand vegetation succession mechanisms but also to feel a sense of reality by linking simulation use to practical work based on curriculum design framework.

Keywords: *Simulation use, Sense of reality, Curriculum design, Vegetation succession*

BACKGROUD

Technologies play an important role in the teaching and learning of science at school. One such technology is simulation, which supports the active learning, not the passive learning, of complex systems in nature that are difficult to deal with in the school laboratory. For example, simulation shows students phenomena and processes of the microscopic motions of atoms and molecules, as well as macroscopic movements of heavenly bodies, large temporal-scale vegetation succession etc. By operating simulation parameters and by observing the results, students can acquire knowledge regarding complex systems (Wellington, 2004).

It has been pointed out, however, that the use of simulation poses a problem relating to the sense of reality (Rosenbaum et al., 2007). The problem is that students experience a virtual world, presented by simulation, as a world quite different from the actual world. For example, although the use of 3D and other technologies gives greater depth and reality to the world presented by simulation, that world is still "heavily" virtual. As a result, while students are interested in simulation, they do not find the reality of the actual world in the simulation.

However, it is possible to resolve the problem regarding the sense of reality. Attempts have been made to resolve the problem by developing simulation using new technologies. One example is "Participatory Simulation" (Colella, 2000), in which learners act as agents and focus on experiencing the simulation using mobile computers. By helping learners physically experience a virtual world, this simulation helps them link the virtual world and the real world. "Environmental Detectives" (Squire & Klopfer, 2007) and "Outbreak@The Institute" (Rosenbaum et al., 2007) are simulations integrating mobile computers and GPS. These simulations offer a good combination of virtual world and real world. Traveling in the real world, learners can experience simulation presented during their travels.

While many earlier studies toward resolving the sense-of-reality problem in simulation have focused on the use of new technology, few studies have focused on curriculum design. Studies that focus on curriculum design include those on how to integrate instruction and learning activities using simulation with practical work, such as field activities, as well as on how to design such activities.

The importance of such studies lies in acquiring views leading to effective use of existing excellent simulations. It has been said that, in science curriculums, it is not the isolated use of technologies, but the integrated use of technologies and practical work that is effective in teaching and learning (Osborne & Hennessy, 2003). If the sense-of-reality problem in simulation is resolved by improving curriculum design, it may be possible to eliminate the shortcomings of existing excellent simulations and continue using them. However, few studies have been made that propose such views for curriculum design.

With this background, the present research proposed "component mapping of simulation and practical work," a new framework of curriculum design. The research featured a experiment in which elementary school students learned vegetation succession, a large temporal scale and complex system in nature, through simulation and outdoor observation. Through the experiment, it was examined whether the elementary school students who learned the curriculum based on the framework were able not only to understand vegetation succession mechanisms, but also to feel a sense of reality.

A CURRICULUM DESIGN FRAMEWORK FOR LINKING SIMULATION USE TO PRACTICAL WORK

The framework proposed in the present research was below (**Figure 1**):

(a) Identifying components that can be experienced directly in practical work from simulation components.

(b) Designing practical work to ensure that learners link simulation and practical work through the direct experience mentioned in (a).

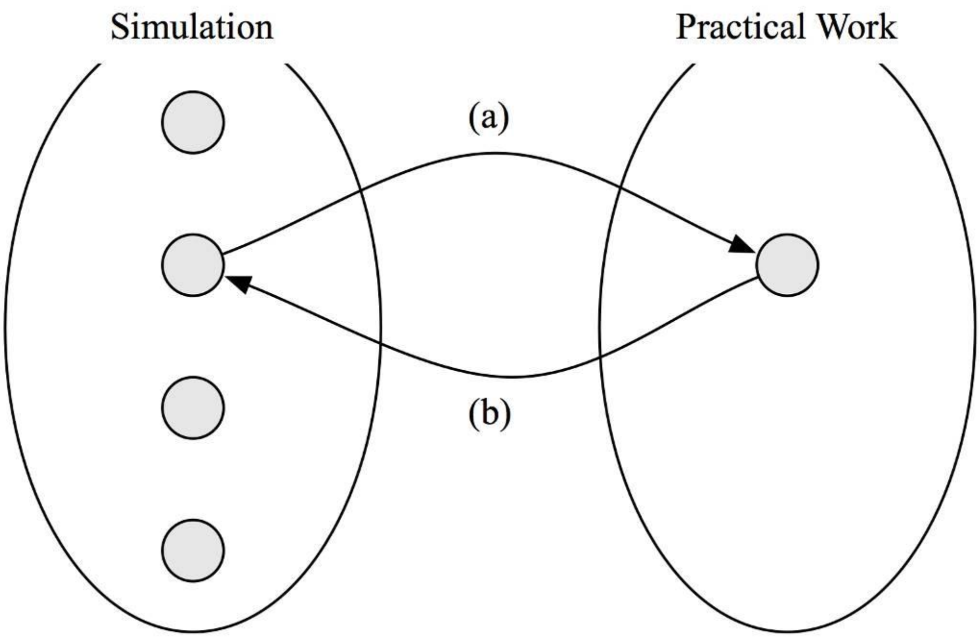

Figure 1. A curriculum design framework

On the basis of this framework, what type of curriculum can be designed? This is explained with the example of vegetation succession, which was dealt with in the experiment of present research. The vegetation succession simulation has components, such as vegetation, time, succession, disturbance (landslide and tree-cutting) and interactions. Of these components, vegetation and disturbance are actually observed outdoors. While vegetation is almost always observed easily, disturbance, which occurs infrequently, is relatively rarely seen. In this regard, according to element (a), vegetation was identified as the component. Also, according to element (b), practical work was designed in which students experienced virtual vegetation succession through use of simulation, then observed some sites with different vegetation in outdoor activities and learned the disturbance and vegetation of these sites through use of simulation results.

EXPERIMENT IN WHICH ELEMENTARY SCHOOL STUDENTS LEARNED VEGETATION SUCCESSION

PARTICIPANTS

The experiment was implemented in a sixth-grade class (36 students aged 11 to 12 years) in a elementary school in Japan, where one of the authors worked.

SIMULATION

The simulation developed by Deguchi et al.(2009) was used in the experiment (**Figure 2**). This simulation, which enables the user to experience vegetation succession, was developed with reference to "The Floristic Relay Game" (Ortiz-Barne et al., 2005). The simulation is designed for learning relationships between vegetation succession and its factors, such as disturbance and interactions. The simulation features the following six types of plants: Japanese Mallotus (*Mallotus japonicus* (Thunb. ex Murray) Mueller-Arg.), Red small berry (*Rubus microphyllus* L. fil.), Quercus serrata (*Quercus serrata* Thunb. ex. Muuray), Red Pine (*Pinus densiflora* Sieb. et Zucc.), Longstalk holly (*Ilex pedunculosa* Miq.) and Castanopsis (*Castanopsis sieboldii* (Makino) Hatusima ex Yamazaki et Masiba). Earlier studies have shown that learners who used the simulation were able to understand basic vegetation succession mechanisms (relationships between disturbance and vegetation succession, as well as relationships between interactions and vegetation succession) (Deguchi et al., 2009).

CURRICULUM

The curriculum comprised two activities: the use of simulation and outdoor observation. In the former activity, student groups, each consisting of six persons, used the simulation, then discussed relationships between disturbance and vegetation succession, as well as between interactions and vegetation succession, while referring to the simulation results (**Figure 3**). In the latter activity, after the simulation, the students went to a neighboring mountain, observed vegetation of the six types of plants featured in the simulation at three sites with early, middle and late succession stages and considered the disturbance and interactions at the sites while referring to the simulation results (**Figure 4**). The former and latter activities both took two hours, for a total of four hours.

Figure 2. The simulation designed for learning relationships between vegetation succession and its factors

EVALUATION

This experiment was evaluated in terms of the following two points: (1) Did the elementary school students who participated in the experiment understand basic vegetation succession mechanisms? and (2) Did the students feel that the vegetation succession experienced in the simulation was an event that actually occurred in the real world of nature?

Figure 3. Curriculum activity: use of simulation

For point (1), free-writing style examinations were carried out before and after the learning of the curriculum, regarding the relationships between disturbance and vegetation succession, as well as between interactions and vegetation succession. These examinations took approximately 10 minutes. In analyzing the each examination, a four-point scale was used to assess the answer students gave to the examination. A maximum score meant that the student explained vegetation succession mechanisms with technical terms students learned through the curriculum, such as dominant plant species of early stages, middle stages and late stages. Two points was assigned if the student explained vegetation succession mechanisms, but did not use technical terms. To merit a score of one the student mentioned regularity of vegetation succession, but did not explained its mechanisms. Two graders scored students' answer independently. The rates of agreement were more than 90%. About the mismatched point, it was settled by the discussion of two graders.

Figure 4. Curriculum activity: outdoor observation

For point (2), after use of the simulation and after outdoor observation, questionnaires were distributed regarding the sense of reality of vegetation succession experienced in the simulation. Questionnaires contains 13 items. These items ask students if they think the increase and decrease of number of plants, and the disturbance will really happen. These items were answered using a five-stage Likert scale: "Think so," "Somewhat think so," "No opinion," "Don’t quite think so," and "Don’t think so." The questionnaire was administered simultaneously to all students. These questionnaire took approximately five minutes. In analyzing students' answer, "Think so" is scored five points, "Somewhat think so" is scored four, "No opinion" is scored three, "Don’t quite think so" is scored two, and "Don’t think so" is scored one.

RESULTS

DID THE ELEMENTARY SCHOOL STUDENTS WHO PARTICIPATED IN THE EXPERIMENT UNDERSTAND BASIC VEGETATION SUCCESSION MECHANISMS?

Figure 5 & 6 shows the result regarding the understanding of basic vegetation succession mechanisms. Wilcoxon signed-ranks test were conducted for each scores. It was found that, regarding both relationships between disturbance and vegetation succession and between interactions and vegetation succession, the scores of the examination conducted after learning the curriculum were significantly higher than those of the examination carried out before learning (Z=-4.38, p< 0.01; Z=-5.47, p< 0.01). From these results, it can be said that students who participated in the experiment understand basic vegetation succession mechanisms.

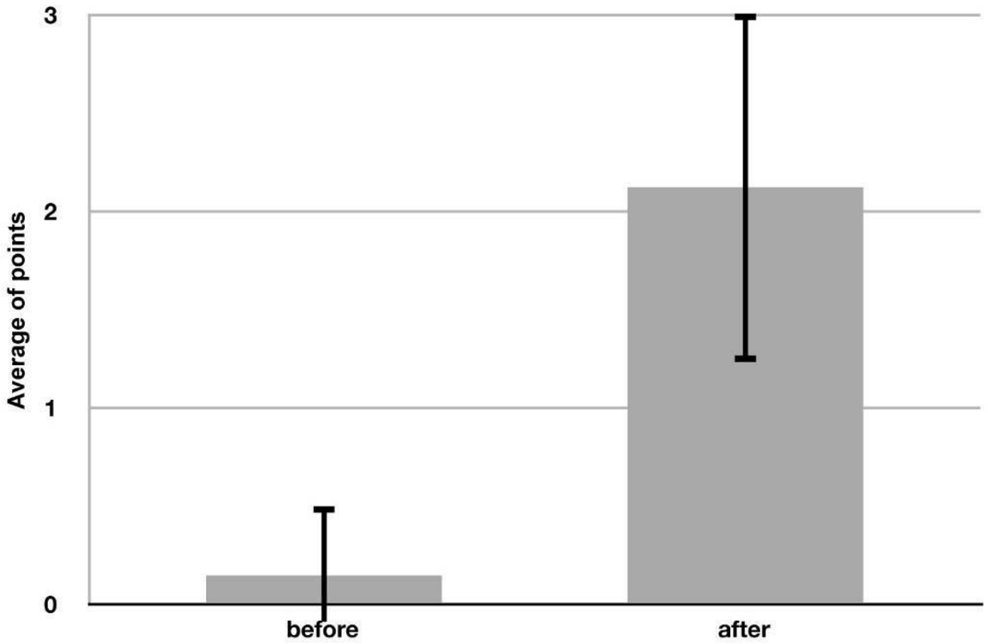

Figure 6. Average and standard deviation of the free-writing style examination regarding the relationships between interactions and vegetation succession

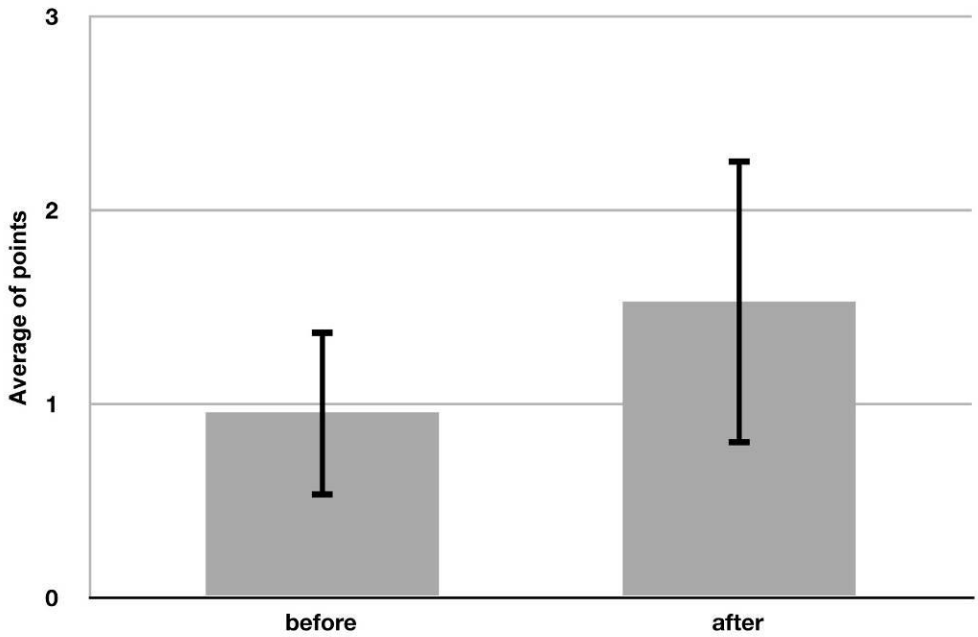

Figure 5. Average and standard deviation of the free-writing style examination regarding the relationships between disturbance and vegetation succession

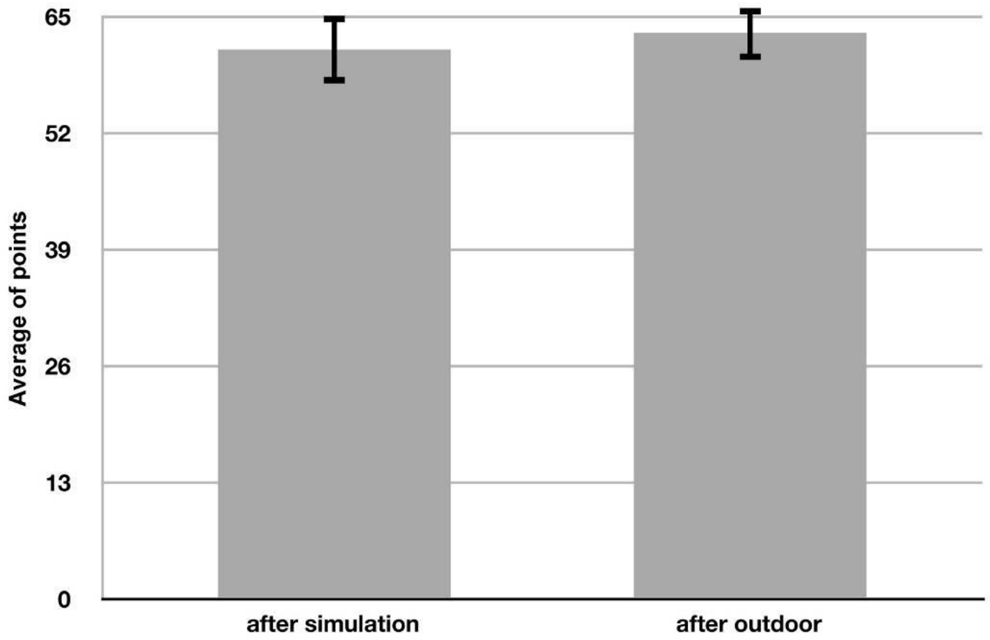

Figure 7. Average and standard deviation of questionnaires regarding the sense of reality of vegetation succession experienced in the simulation

DID THE STUDENTS FEEL THAT THE VEGETATION SUCCESSION EXPERIENCED IN THE SIMULATION WAS AN EVENT THAT ACTUALLY OCCURRED IN THE REAL WORLD OF NATURE?

Figure 7 shows the result regarding the sense of reality of vegetation succession experienced in the simulation. Wilcoxon signed-ranks test were conducted for total scores. The total scores of after the outdoor observation was significantly higher than that after the simulation (Z=-3.07, p< 0.01). From these results, it can be said that students feel that the vegetation succession experienced in the simulation was an event that actually occurred in the real world of nature.

CONCLUSIONS AND FUTURE WORK

The results of this present research revealed that the elementary school students who learned the curriculum were able to understand basic vegetation succession mechanisms. The results also showed that, although the elementary school students did not feel so much of a sense of reality after use of the simulation, they felt it after the outdoor observation. Under normal conditions, simulation and practical work support students' learning individually. On the one hand, simulation support students understand mechanisms of complex systems, and on the other hand, practical work support that student feel a sense of reality. In the present research, by intergration simulation and practical work in an effective manner, both support understanding and feeling were achieved coincidentally. In this sense, results of present research suggests that "component mapping of simulation and practical work," the curriculum design framework proposed in this present research, is effective.

The future challenges are the following two points: to ensure the generality of the present research results by carrying out experiments involving many more learners, and to create a more detailed framework and clarify its applicable scope by considering whether the framework is applicable not only to vegetation succession, but also to other areas or topics.

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INTERNATIONAL COLLABORATIONS THROUGH YOUNG SCIENTISTS INVITATION PROGRAMS TO JAPAN: JSPS SUMMER PROGRAM

Chihiro YAMANAKA

Japan Society for the Promotion of Science (JSPS)/Graduate School of Human Development and Environment, Kobe University, JAPAN

chihirocean@gmail.com

Shigenori INAGAKI

Graduate School of Human Development and Environment, Kobe University, JAPAN

inagakis@kobe-u.ac.jp

ABSTRACT

International scientific collaboration is necessary for survival in a knowledge-based and increasingly globalized world. This paper evaluates the practices of the Japan Society for the Promotion of Science (JSPS) Summer Program, which invites pre- and postdoctoral researchers from North America and Europe to study in Japan. The questionnaires and comments from the final report distributed to the participants revealed that, in spite of the program's short length, the participants believed that the program succeeded in the areas of professional development, international collaboration, and scientific contribution. These findings indicate that the program achieved its goal of helping excellent young researchers initiate scientific relationships that will better enable future collaborations involving Japanese universities and research institutions. Similar international programs for scientists could apply and benefit from the overall experiences of the program.

Keywords: *International Collaboration, Career Development, JSPS Summer Program, Fellowships*

1. INTRODUCTION

1.1. Mobility of Human Resources and International Collaboration

Mobility of human resources in science and technology has become a central aspect of globalisation (OECD, 2008). The Japanese government has been driving an aggressive agenda to promote science and technology, which support domestic economic growth in the long term. Today, the government strongly advocates inviting the most talented and qualified individuals to study in Japan, as evidenced by measures such as the 300,000 International Students Plan and the Project for Establishing Core Universities for Internationalization, which were enacted in 2008. Thus, the expansion of exchanges among universities and the acceptance of international students has been a key governmental policy.

Moreover, international cooperation is a proven mechanism for promoting excellence in scientific research (UNESCO, 1999). Scientists collaborate across borders for a variety of reasons: to bring together the most talented and qualified individuals; to pool intellectual, technological, and financial resources; and to effectively address scientific questions (UNESCO, 1999). While we still need to address the problem of college-educated students having difficulty finding scientific careers (e.g., NAS et al., 1996; Ogawa, 2004), for young scholars, postdoctoral fellowships can serve as a launching pad to an academic career that is almost as important as the Ph.D. programs in which they initially trained (Ronald, 2009).

1.2. The Role of Scientific Academies

JSPS has played a pivotal role in the administration of a wide spectrum of domestic and international scientific programs since its establishment in 1932. The society implements a variety of researcher-invitation programs for various career stages and serves to support researcher exchange (MEXT, 2008). The JSPS Summer Program is tailored to researchers at the start of their careers.

This research looks at whether the program is a legitimate strategy for attracting individuals to the profession and for nurturing the next generation of scientists. Although some earlier works looked at fellowship programs from various perspectives, few research studies have evaluated the achievements of fellowships in Japan. Moreover, in the last 20 years, limited analysis has been conducted on the data compiled about young scientists by the organizations involved; this is attributable to the fact that their international activities do not focus on education first. Of course, many factors influence such achievements, and it is difficult to untangle them, but there are enough existing data and information to identify some of the links between mobility and broader science and innovation outcomes (OECD, 2008).

2. OBJECTIVES AND METHOD

This paper evaluates the 2008 JSPS Summer Program primarily by deciphering participants' comments in questionnaires and a final report. The author's ongoing observation of the program provided additional support for the evaluations in this research. We conclude the paper with a discussion of future implications.

One way to view the problem is from the perspective of higher education, considering it "is required to be characterized by its international dimension: exchange of knowledge, interactive networking, mobility of teachers and students, and international projects" (UNESCO, 1998). We initially laid aside "mobility of teachers and students" and focused on the following dimensions, paraphrased in our words:

- Exchange of Knowledge → Professional Development
- Interactive Networking → International Collaboration
- International Projects → Scientific Contribution

3. PROGRAM OVERVIEW

This section focuses on the general aspects of the program. The program began in 1990 under the auspices of the Ministry of Education, Culture, Sports, Science and Technology (MEXT) and in collaboration with the National Science Foundation (NSF) as a program in which scholars were invited to Japan. Since its transfer to JSPS in 2003, other countries have participated in the program, which encourages excellent young researchers to initiate scientific relationships that will better enable future collaborations involving Japanese universities and research institutions. Owing to its successful history and vast accumulation of practical knowledge, the program should be used as an example when JSPS or other organizations institute similar invitation programs.

As Figure 1 shows, the program is implemented under the joint auspices of JSPS and the Graduate University for Advanced Studies (Sokendai). Sokendai arranges a one-week orientation and final meeting at the end of August. JSPS's overseas offices support recruitment and hold pre-departure meetings in cooperation with the headquarters of the partner academies in each country.

Each year, JSPS receives applications through the following overseas academies: NSF, British Council, Centre National de la Recherche Scientifique (CNRS), Deutscher Akademischer Austauschdienst (DAAD), and Canadian Embassy. Each nominating authority selects its awardees, or Fellows. Table 1 lists the 2008 Fellows.

The program lasts for two months each summer, as shown in Table 2. The Fellows first take part in an orientation to the Japanese language, cultural experience (comprising a home stay and other components such as folding papers and tea ceremonies), and a public poster session. Next, participants have an opportunity to participate in cooperative research at a Japanese university or research institute. At the end of August, the participants get back together to present reports on their summer experiences. In terms of financing, Fellows receive round-trip airfare, maintenance allowances, a domestic research-trip allowance, overseas travel insurance, and allowance for research-related expenses.

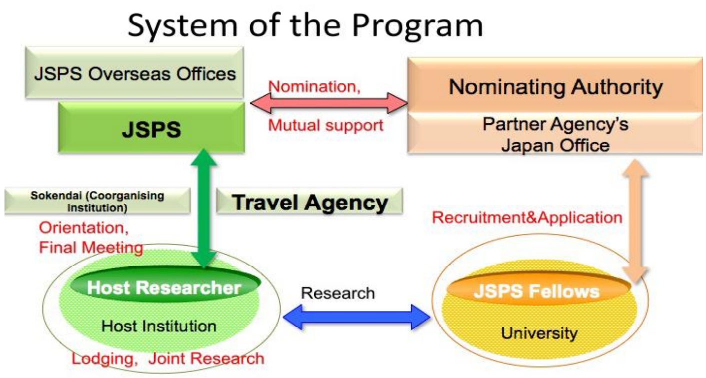

Figure 1. System and organizers

Table 1. Quota for each country in 2008

Country (Nominating Authority)	U.S. (NSF)	U.K. (British Council)	France (CNRS)	Germany (DAAD)	Canada (Canadian Embassy)	Total
Quota	63	11	8	14	18	114

Table 2. Activities in 2008

Week(s)	Activities
1	Arrival and Registration
1	Move to Camping Place, Opening Ceremony
1–2	Orientation (Language Classes, Cultural Experience, Poster Presentation, Home Stay, and Special Lectures)
2	Move to Host Institutions
2–8	Cooperative Research, Report Submission, Informal Interview
8	Move to Tokyo, Final Meeting (Representatives' Oral Presentation, Farewell)
8	Departure

4. RESULTS

We asked for feedback from the participants (i.e., Fellows and their host researchers) in the form of questionnaires and comments, if any, in their final reports.

4.1. Questionnaires

As shown in Tables 3 and 4, to identify participants' impressions of the program and their research experiences, we focused on survey data extracted from a questionnaire originally conducted in 2008 at the conclusion of the program. Targeting 114 Fellows and 114 host researchers who were involved in the program, the questionnaire asked about the participants' reasons for participating, their assessment of the program, and Fellows' achievements, including whether they thought there was any possibility of future collaboration. Among those asked to participate, 109 Fellows (96%) and 45 host researchers (39%) responded to the questionnaires. Fellows were from a range of academic levels: 16 were working on their master's degree, 90 were in a doctoral program, and 3 were postdoctoral researchers. We derived our major research findings from questions F7, F8, F10, F12, H4, H5, H6, and H9.

We first looked at professional development. Figure 2 shows the participants' evaluations of whether the initial research objectives were achieved. On the Fellows' questionnaire (question F8: To what degree did you achieve your research objective?), half of the people considered their achievements to be "satisfactory," while the host researchers mostly responded "beyond expectations" and "fully accomplished" in response to question H6 (To what degree did the Fellow achieve his/her research objective?). Most participants thought the research objectives were at least satisfactory. The next part will discuss the fact that most host researchers evaluated the Fellows' achievements higher than the Fellows did.

Table 3. Questionnaire Given to Fellows.

	Fellows' Questionnaire
F1	How did you learn about the program?
F2	What is your primary motive for participating in the program?
F3	Were the pre-departure communications useful to you in preparing to participate in the program?
F4	Was the information provided in the orientation sufficient?
F5	Were the Japanese language classes appropriate and effective?
F6	Were you satisfied with the introductory program to Japanese culture?
F7	How often did you exchange research opinions or ideas with Japanese colleagues?
F8	To what degree did you achieve your research objective?
F9	What aspects of the program were the most interesting or valuable to you?
F10	Was this research experience in Japan useful in your professional development?
F11	What is your evaluation of the overall program?
F12	What do you think is the possibility of conducting your future research in Japan?

Table 4. Questionnaire Given to Host Researchers

	Hosts' Questionnaire
H1	How did you become acquainted with the Fellow?
H2	What is your primary motive for participating in the program?
H3	Was JSPS's preliminary information useful to you after the fellowship was awarded?
H4	What do you think of setting the fellowship tenure at two months?
H5	How often did you exchange research opinions or ideas with the Fellow?
H6	To what degree did the Fellow achieve his/her research objective?
H7	Did you experience any problems in hosting the Fellow?
H8	What is your evaluation of the overall program?
H9	Do you intend to continue collaborative research with the Fellow after his/her fellowship ends?

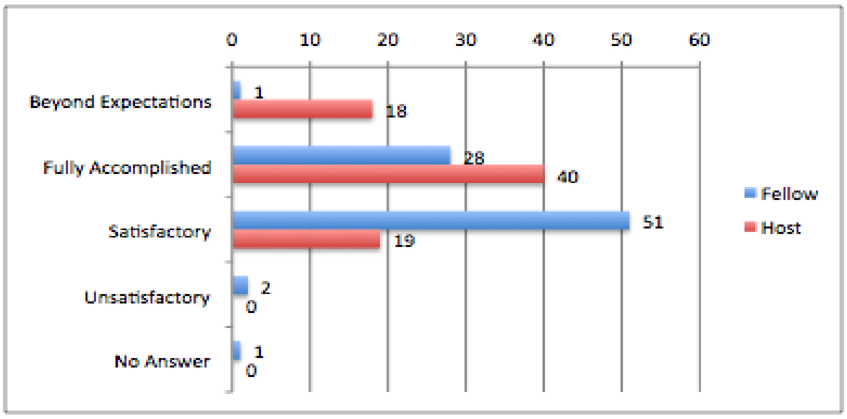

Figure 2. Evaluation of whether the initial research objectives were achieved (questions F8 and H6) (%)

We also gauged professional development by the responses to question F10 (Was this research experience in Japan useful in your professional development?). Ninety-nine percent of the Fellows answered "yes." The question was followed by four explanations from which the participants could choose: knowledge or information acquired during the program, contacts established with Japanese collaborating researchers, international research experience, and experience of living in a foreign country. As most people marked all three explanations, as shown in Figure 3, we assumed that every aspect identified was useful to the Fellows' professional development.

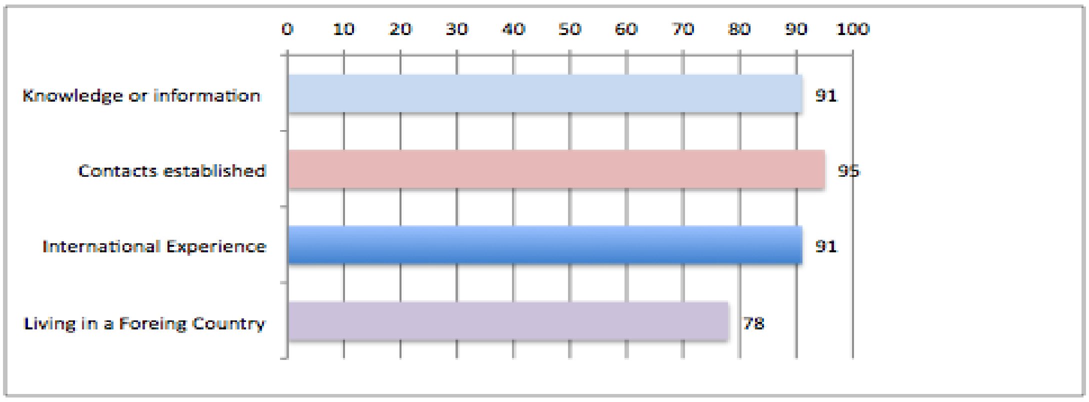

Figure 3. Professional development (question F10) (%)

We next looked at international collaboration. Questions F7 (How often did you exchange research opinions or ideas with Japanese colleagues?) and H5 (How often did you exchange research opinions or ideas with the Fellow?) represent the frequency of oral communication between Fellows and Japanese researchers. As shown in Figure 4, both Fellows and host researchers, including Japanese colleagues, discussed research at least "occasionally" and many replied "often." We note that it is not unusual for host researchers to leave Japan for conferences held overseas during the summer, and Japanese universities set summer holidays in the middle of August; therefore, it is possible that conversations would have taken place more often if there were more opportunities for interaction.

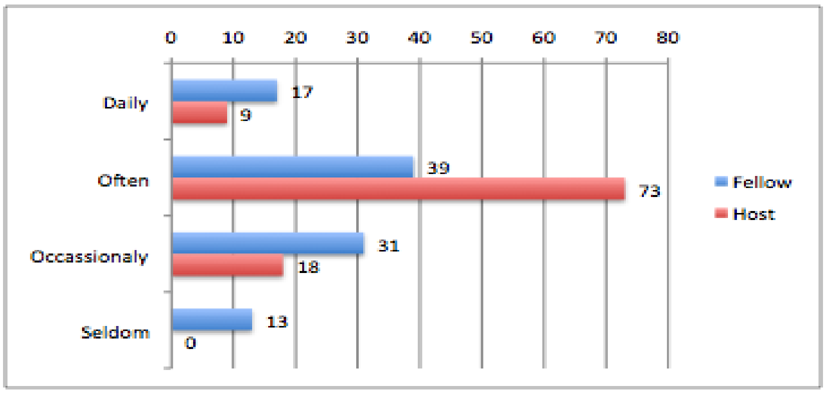

Figure 4. Frequency of research discussions with Japanese colleagues (questions F7 and H5) (%)

Lastly, we looked at the results for scientific contribution. Figure 5 shows the results of questions F12 (What do you think is the possibility of conducting your future research in Japan?) and H9 (Do you intend to continue collaborative research with the Fellow after his/her fellowship ends?), which deal with the possibility of future collaboration between the Fellow and host groups. We cannot make a simple comparison between the two questionnaires because the Fellow's questionnaire did not have a "Have already/am planning to" choice; however, the results were clear that the majority of both Fellows and host researchers were favorably inclined to continuous or future collaborations.

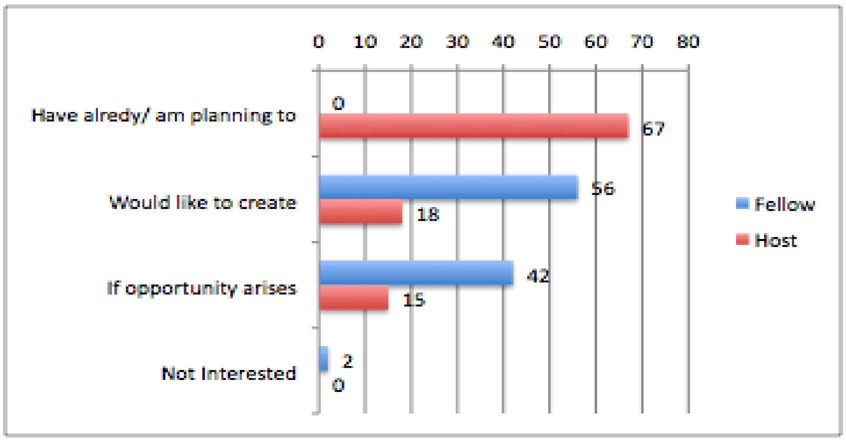

Figure 5. Possibility of returning to Japan (question F12) and intention of continuing collaboration (question H9) (%)

On the other hand, as the results of question H4 (What do you think of setting the fellowship tenure at two months?) show, most (64%) host researchers thought the term was insufficient, while 36% answered "just right," as shown in Figure 6. We found similar results in the comments from both host researchers and Fellows, which we will discuss in the next section.

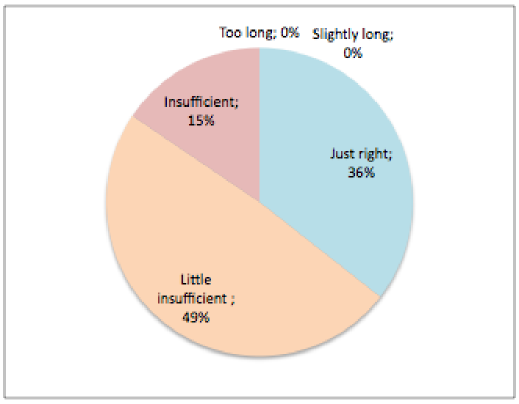

Figure 6. Host researchers' thoughts on the fellowship tenure (%)

We did not focus on the answers to question F9 ("What aspects of the program were the most interesting or valuable to you?") for fear of compromising individuals' anonymity, although the answers provided a detailed picture of the wide range of impressions held by the participants.

4.2. Comments from Reports

The data discussed in this section is based on the final report from all the participants in 2008. The last part of the report offered Fellows and hosts an opportunity to comment on their participation and research in Japan. It is important to emphasize that the comments section was optional, while submitting the report was mandatory. Of the 114 reports submitted, 106 participants (46.5%) of 74 Fellows and 32 host researchers provided comments.

In an attempt to examine the comments, we divided them into three categories, as shown in Table 5. Among all the respondents, 68 comments (29.8%) from 52 Fellows and 16 host researchers fell under Professional Development, 67 comments (29.4%) from 42 Fellows and 25 host researchers fell under International Collaboration, and 33 comments (14.5%) from 12 Fellows and 21 host researchers fell under Scientific Contribution.

Table 5. Achievements represented in the comments in the final report

Categories	Comments
Professional Development	*Fellow C*: "The experience of working in a foreign laboratory and the unique opportunity to collaborate with some of the leading scientists in the field of geochemistry has been a real honor for me." *Fellow F*: "During each visit to other laboratories and facilities throughout Japan, discussions were carried out on the differences in research approaches between American and Japanese laboratories, as well as how the culture and background of each geographical area impacts the respective research process. Discussions and exchanges of ideas have the potential to lead to numerous future collaborations, and many new ideas for future research directions have been created. This trip has proved fruitful not just based on meeting the stated research objectives, but also in better understanding the research culture in Japan." *Fellow G:* "This program allowed me to gain insights and perspectives I would have been unlikely to experience at my home university. In the short term, I intend to continue pursuing several of the results achieved this summer. The product of this will be joint publications with Japanese researchers." *Fellow H*: "At the end of two months, I am now proficient in using the microscope and analyzing images collected with it. I also have a much clearer idea as to what the technology's capabilities and limitations are."

	Fellow I: "This being my first international research experience, I was truly overwhelmed by the friendship, professionalism, and quality of research shared with me. My time here helped me grow in every positive way." *Fellow L*: "The program was one of the most meaningful experiences of my academic career and exposed me to a non-Western perspective on science." *Fellow Q*: "I improved my experimental skills and have had access to experimental equipment not available in Paris, such as an optical parametric amplifier and a two-color pump-probe measurement. I also had the opportunity to give a seminar in order to present my experimental results about spin physics in InAs/GaAs quantum dots. [Professor's name], who is internationally recognized as a leader in non-linear optics in semiconductors, proposed that I attend an international conference in Japan to present my research during the poster session, as well as to visit [university name], which has developed many experiments to study Terahertz physics." *Fellow V*: "Overall, my research experience in Japan was very rewarding, both personally and professionally. Although I did not accomplish all of the goals I had set out for the summer, the program allowed me to branch out and work in a new and exciting field of application that is of definite interest to myself and machine learning. …Finally, performing research in an international setting was a very eye-opening experience; one which I believe will have a positive impact on my future academic career." *Host of Fellow E*: "I am sure that her experience will be beneficial for her career development and enforce a Japan-U.S. scientific exchange and interactions as a member of the next generation of international science professionals."
International Collaboration	*Fellow A*: "I certainly plan to continue this work after my return to the U.S., in collaboration with my new colleagues at [institute name]. I hope to have the opportunity to work in Japan again in the future." *Fellow D*: "I've really enjoyed spending time with fellow researchers from around the world. Through the Summer Program I was able to make meaningful professional contacts in Japan and the U.S." *Fellow E*: "This program has really helped opened my eyes to the international scientific community." *Fellow G*: "In the long term, I believe that I have forged relationships this summer that will turn into lasting collaborations. While I certainly look forward to returning to Japan, I also anticipate some day in the future when I can host Japanese researchers back in the United States." *Fellow L*: "Additionally, the networks I have formed during my time in [lab's name] have opened the door to exciting future collaborations." *Fellow N*: "My time in [professor's name]'s lab has given me a unique opportunity to further my research and collaborate with world leaders in the field of molecule-based magnetism. It has been a fantastic experience, both scientifically and culturally, and I hope it is the beginning of a long and fruitful collaborative relationship." *Fellow O*: "I made many interesting contacts with great researchers in my field, and we exchanged interests in many interesting discussions." *Fellow P*: "Two months is a very short time in research, but it is a perfect amount of time to try out a new idea or a theory in a new environment with different expertise and an alternative viewpoint. We intend to pursue this research in the future and also pursue a side project with bone marrow stem-cell treatment for skin disorders." *Fellow T*: "Besides experiencing the academic and research environment in Japan, I was able to establish contacts not only with Japanese academics but also with researchers from other participating countries of the summer fellowship as well." *Host of Fellow M*: "While the summer program is short, [Fellow's name] has been working diligently and making a lot of progress in his research. We also had a lot of discussions and identified challenging research topics in which we can continue to cooperate in the future."
Scientific Contribution	*Fellow J*: "Both my supervising professors and the other students in my lab were very helpful, and their assistance made it possible to achieve significant results in the limited time available." *Host of Fellow C*: "He has worked hard and observed data that are very important in the field of isotope geochemistry." *Host of Fellow E*: "[Fellow's name] was a very energetic, highly motivated individual. She conducted herself with the utmost courtesy and respect here in Japan, and I think she has been able to contribute greatly to our on-going

	project on Yakushima with her study design integrating well into the overall focus of our research.”
	Host of Fellow H: “One of the excellent outcomes of this program is that a new collaboration has been established. The experiments planned were highly challenging, but we have obtained highly exciting initial results, which can be continued in the collaboration between [name of U.S. doctor] and my laboratories.”
	Host of Fellow K: “She has eagerly studied the research subject and obtained significant results. Her work is greatly helpful and important for our project. Her single-minded devotion to the study has impressed the graduate students in our laboratory.”
	Host of Fellow R: “His STM study on binary molecular assembly has been done as a series of on-going collaborations between [German institute name] and [Japanese institute name]. He found a new combination of molecules to form well-mixed arrays on the surface of Cu (100). This work made a great contribution to our collaboration and created an opportunity for further experiments.”
	Host of Fellow S: “The visit of [Fellow’s name] profited the entire research team in the department both on academic and personal levels. Interesting discussions arose from [Fellow’s name]’s research on the nanocomposite microstructure manufacturing method. Also, the interactions with the students were respectful and friendly.”
	Host of Fellow W: “Even in a short visit, [Fellow’s name] made some fruitful experiments; some of the preliminary results were presented in an International Conference held in Sendai. His presence truly stimulated Japanese students through daily laboratory activities including academic discussions, field experiments, and gate-ball games. I believe the program was very fruitful for both countries’ students.”

From the results in Table 5, in the category of Professional Development, the Fellows felt the program was useful for their career development, as evidenced by Fellow L’s remark: “The program was one of the most meaningful experiences of my academic career and exposed me to a non-Western perspective on science.” The comments from the host researchers (e.g., Host of Fellow E) gave the same impression. Second, in the category of International Collaboration, as Fellow T remarked, “I was able to establish contacts not only with Japanese academics but also with researchers from other participating countries of the summer fellowship as well,” and host researchers (e.g., Host of Fellow M) offered similar comments. Third, in the category of Scientific Contribution, a considerably larger number of host researchers than Fellows expressed that the Fellows made a scientific contribution, such as the comment from the host of Fellow C: “He has worked hard and observed data that are very important in the field of isotope geochemistry.”

Therefore, typical comments, as gleaned from interviews and reports, were as follows:

- Professional Development: This program allowed me to gain insights and perspectives I would have been unlikely to experience at my home university.
- International Collaboration: I would like to continue the research project with new colleagues and hopefully invite Japanese colleagues to my laboratory.
- Scientific Contribution: I made a great contribution, producing significant results for the field or very important data for the ongoing project.

Many of the comments noted the insufficiency of the term but did so in optimistic or favorable contexts, as follows:

- “My research goals proved too ambitious for a single summer, and it proved impossible to learn the necessary data-processing techniques, process the data, and develop models all in a single summer” (Fellow A).
- “Although the period of stay was too short to finish something, I believe this program is effective for both students and advisors” (Host of Fellow U).

In addition, the term is intentionally set as a trial shorter period; those who wish to prolong their stay may do so for up to 90 days.

4.3. Evaluation of the Program

In this section, we present a summary of the findings. Participants considered the program to be effective at providing an opportunity to build professional development, facilitating international collaboration, and creating scientific contributions, while they thought that the term was slightly insufficient.

Particularly with regard to international collaboration, the Fellows built networks among Japanese researchers and participants from other countries, thus obtaining interdisciplinary perspectives through the program, as evidenced by Fellow D's remark: "I've really enjoyed spending time with fellow researchers from around the world." Bringing together researchers with different knowledge and backgrounds could facilitate an exchange of ideas, thereby creating a breeding ground for innovative work as well as providing another layer of support to those involved in the fellowship (Halsey et al., 2007).

Additionally, as the host of Fellows K, S, and W noted, the visiting young researchers inspired young Japanese researchers-to-be to expand their perspectives. It seems that "in the workplace, knowledge spreads to colleagues, especially those in close contact" (OECD, 2008).

5. CONCLUSIONS

As discussed, the program clearly achieved two goals: (1) it is a legitimate strategy for attracting individuals to the profession and for nurturing the next generation of scientists, and (2) it contributed to the commencement of international collaboration, as it was initially framed to do. It is also noteworthy that many of the Fellows achieved various non-science goals and felt confident in conducting research in a different country for two months.

The evidence accumulated in this paper also provides suggestions for further research. Since there continues to be ambiguity among some descriptions, it is necessary to modify the questionnaire so that the results reveal more precise achievements by improving the choices for each item. Doing so would provide better results to measure the future achievements of the program. In addition, with regard to strengthening the findings, we should explore the impact of the participation of former Fellows (so-called JSPS alumni) and accumulate the questionnaire results obtained from previous years.

In conclusion, providing an opportunity for young researchers to conduct research in a different country promotes their professional development, encourages knowledge exchange, and forms global scientific networks. Although the findings indicated the need to prolong the fellowship term to achieve the initial research goals, we expect that such feelings of insufficiency could lead to future research activities within the networks established through the program. Therefore, we hope that JSPS, as one scientific academy, works toward continuing and formulating such programs, so that it can serve as a springboard for international collaborations in science and technology. This would also benefit the countries that send researchers, because the emigration of skilled researchers and scientists can be beneficial for the creation and diffusion of knowledge in their country of origin (OECD, 2008). In addition, as several other fellowship schemes administered through governmental organizations are currently available, it would be possible to profit from the knowledge and experience of the fellowships that are already being offered, thereby increasing the global stock of knowledge.

5. ACKNOWLEDGMENTS

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THE TEACHING OF SCIENCE AND MATHEMATICS IN ENGLISH: A CRITICAL APPRAISAL

Suan Yoong

Sultan Idris University of Education, Malaysia

(yoongsuan@yahoo.com)

Lee Yuen Lew

Long Island University, C. W. Post Campus, USA

(leeyuen.lew@liu.edu)

ABSTRACT

In a pluralistic society, language and medium of instruction have always generated controversies and debates. The teaching of science and mathematics in English in many developing countries, especially former British colonies is an extension of these debates. Pedagogically speaking, science and mathematics contents are cognitively more demanding and require learning tasks that involve abstract and formal thought. What does research evidence say about learning of STM subjects in English by non-speakers of English? Does the practice of teaching STM subjects in English to non-speakers of English go against scientific evidence about learning? What level of English competency must non-speakers of English acquire before they are proficient enough to use it to acquire the contents of STM or other subjects? What evidence supports that children can manage the transition to switch to the learning of content in a second language (English)? This paper seeks to address these questions by providing a comprehensive review of research findings relating to the acquisition of English as a second language in a multiethnic student population, highlighting issues and challenges faced in managing the transition to the learning of STM or other subject contents in a second language, notably English.

Keywords: *Teaching of science and mathematics in English, second language acquisition, mother-tongue education*

INTRODUCTION

Parents In many developing countries view English as the language that could help their children towards finding employment and consequently upward mobility. Most former British colonies inherited education systems that consciously propagated English as basis for developing the national education policies. With unequal development of vernacular schooling sustained through policies that combined mediated and unmediated acts of rewards and recognitions, English acquired immense economic value and become a lingua franca in interethnic communication in these countries even after years of independence. It is the language of the elite, power, and privileged. Many parents see it as a means for achieving unlimited vertical social mobility. Indeed, English has emerged as the most important international language for trade and commerce in the epoch of rapid globalisation. Books, journals, research or technical papers, and popular writings, notably in science, technology and mathematics (STM), and the Internet are predominantly in English. Given the geometric growth of knowledge and development in information, English has become the worldwide norm to access STM information in the Internet. More than 63 nations have recognized it as the official language (Mackey, 1984:434). In many of these countries, English has also taken center stage and is used in all high domains, notably the government and sociopolitical administration, education, economy, and diplomacy.

As a newly industrialising country that has benefited from a very rapid rate of economic growth, Malaysia requires a large workforce that can effectively access the knowledge and skills in STM to help transform the country into a knowledge-based economy and society by 2020 (Mahathir Mohamad,1991). The decline in the standard of English in Malaysian schools worried government and private sector leaders, who fear that the nation may risk lagging behind economically and loosing competitive edge if they do not respond to the global change of developing a large English-proficient workforce. Improving the standard of English language as well as acquiring cutting edge skills in STM has become a major aspiration of the Malaysian government. Consequently, the Ministry of Education introduced the policy of teaching of STM subjects in English at all levels of schooling based on the belief that this practice will improve both the standard of English language as well as the standards of science and mathematics in Malaysian schools. The policy was implemented in 2004. Although a substantial number of parents supported this controversial policy, oppositions from various quarters were more wide-spread since most Malaysian students are schooled in their mother tongue languages, and are only learning English as a subject formally at the entry level of schooling. After completing a 6-year cycles of implementation and facing wide-spread resistance, the Malaysian government made a round-about turn in its policy and rescinded the policy of teaching STM subjects in English at the primary and secondary school levels with effect from January 2012. The round-about turn in policy again fuels both oppositions and supports from Malaysian parents.

PROBLEM STATEMENT

No one doubts the importance of English, especially as a mean to effectively access the knowledge and skills of science and technology. What is worrying is that, in Malaysia, the switch to teach STM subjects in English ignored the standard practice of curriculum development and readiness for implementation. No study had been carried out to evaluate the effect of teaching STM subjects in English prior to implementation. Research evidences pertaining to the validity of this practice of teaching STM in English were ignored. The dominant rationale is purely market driven based on a commonly prevailing myth hinging on the immense economic value of English language. As Hafriza (2006) justifies:

> “In this age of industrialization and internationalization, we cannot deny future generations the ability to access new frontiers in science and technology simply because of their poor English.” (p. 24)

This commonly prevailing myth had driven many government leaders and administrators into believing that using English as the medium of instruction in schools is the best way to produce an English-proficient workforce, starting as early as possible.

Teaching STM subjects in English at the primary school implies that one is not merely teaching the subject contents but also the target English language system as well to non-speakers of English in a non-English speaking environment. Pedagogically speaking, STM contents are cognitively more demanding and require learning tasks that involve abstract and formal thought. What does research evidence say about learning of STM subjects in English by non-speakers of English? Does the practice of teaching STM subjects in English to non-speakers of English go against scientific evidence about learning? What level of English competency must non-speakers of English acquire before they are proficient enough to use it to acquire the contents of STM or other subjects? What research evidence supports that children can manage the transition to switch to the learning of content in a second language (English)? From a socio-psychological perspective, does the practice of not using a language of instruction that learners understand best goes against scientific evidence about learning? Does the practice transmit the socio-cultural message that one’s own language, culture and experiences have no value in acquiring STM skills?

This paper seeks to address these questions by providing a comprehensive review of research findings relating to the acquisition of English as a second language in a multiethnic student population, highlighting issues and challenges faced in managing the transition to the learning of STM or other subject contents in a second language, notably English. Evaluation studies carried out in Malaysia to assess the impact of implementing the policy of teaching of STM subjects in English are presented.

RESEARCH EVIDENCE

Important facets of intellectual functioning are intimately linked to language development. There is overwhelming evidence from studies in many countries that the learning of basic concepts and intellectual processes in the early stages of a child's development is best established through the language a child understands best, which is usually the mother tongue, before a second language can be used as the learning medium at a later stage (UNESCO, 2008). Whether done through parental choice or otherwise, knowingly or unknowingly forcing a child to accept instruction through a language that one hardly understands goes against scientific evidences about learning, as the following review of research shows.

Language plays a critically important role in classroom learning. Since it is the key to communication and understanding, it is essential that a language that learners understand and speak is used as the language of instruction. It enables the children to participate in the meaningful learning processes according to their evolving capacities and student learning can be accurately assessed. When students can express themselves, teachers can diagnose what has been learned, what remains to be taught and which students need further assistance. When an unfamiliar language is used in instruction, cognitive learning and language learning are confounded, making it difficult for teachers to determine whether students have difficulty understanding the concept itself, the language of instruction, or the language of the test. Extremely high educational demands are required of these learners and consequently few of them have sufficient knowledge of the language of instruction to support them through schooling. Indeed, switching to the learning of content in another language through a language of instruction that a learner hardly understand provides a double set of challenges: not only does one has to learn a new language but also to use that language to learn new knowledge. "It would give rise to a great deal of confusion, producing a lack of clarity of thought and a slowing down of those processes that utilize linguistic mediators" (Lambert, 1977) and it takes years before students can discover meaning in what they are "reading" (Baker 2001; Cummins, 2000; CAL, 2001). While there is evidence that many children did manage the transition to the mainstream education in a second language, they, however, represented the top 10 to 15% of the higher ability students with strong family background or support.

That a child learns better and more productively if learning is done in a language that one understand best is an axiomatic principle of education reiterated by UNESCO since 1953 (UNESCO, 1968/1953). Research has also served to confirm the arguments in support of mother tongue education programs (UNESCO, 2003). Reviews of research put the issue in clearer perspectives, and substantiated the critical connection between primary language skills and academic success (see for example, Dutcher, 1995; 2004; Constantino, 1999; Walters, Davis & Morren, 1999; Thomas and Collier, 1997/2002; UNESCO 2008; Cummins, 1979; 1989; Cummins & Swain, 1986; Skutnabb-Kangas 2000).

The research conducted by Thomas and Collier (2002), in particular makes the strongest empirical argument for mother tongue education. The sheer scope of the longitudinal study, which involved more than 60,000 students in 25 school districts in every region of the USA, makes the results and conclusions difficult to ignore. By following non-English speaking children through grade 11 in selected US schools and by comparing the results of six different levels of educational support in the mother tongue, Thomas and Collier presented a convincing picture of the differential outcomes of these six different approaches: students with four to seven years mother tongue educational support in a quality bilingual program sustain academic achievement and outperform monolingually-schooled students in the upper grades, making a forceful case that language is, indeed, a critical mediating component in effective long-term education.

While Thomas and Collier made no claims about the implications of their research for education in developing countries, they did propose an explanatory model for their findings which can be readily extended to educational experience in developing countries. Indeed, pieces of empirical evidence from studies carried out in Africa, Asia and Latin America do support the educational advantages of mother tongue education: learning to read in their own language provides learners with a solid foundation for learning to read in the second language, outperforming those taught to read in a second language in immersion education (UNESCO, 2008).

In contrast, research with indigenous and minority learners from all over the world also provided plenty of negative evidence suggesting that immersion education models are ineffective, wasteful in terms of human resource development, marginalising language minority children, and resulting in high dropout and illiteracy rates (Macnamara, 1966; Cummins, 1981, 1984; Jeffcoate, 1984; Cummins & Swain, 1986; Cardenas, Robledo, & Waggoner, 1988'; Saville-Troike, 1991; Musker 1993; Baker, 1993; Samuels 1995; Moss & Puma, 1995; Hartshorne 1995; Alexander 1998; Brint, 1998).

Research in the English-speaking countries specifically documented the slowing down effect of the learning process when minority students switch to the learning of content in a second language. Studies show that language-minority students in the English speaking countries in the West are 1.5 times more likely to drop out of school than native speakers (Cardenas, Robledo, & Waggoner, 1988). In learning English as a Second Language (ESL), minority students tend to receive lower grades, are judged by their teachers to have lower academic abilities, and score below their classmates on standardized tests of reading and mathematics (Moss & Puma, 1995). In U.S. schools where all instruction is given through ESL, non-native speakers with no schooling in their first language take 7-10 years to reach age- and grade-level norms (Cummins, 1981). Immigrant students who have had 2-3 years of schooling in their first language (in their home countries) take at least 5-7 years to reach age- and grade-level norms (Cummins, 1981; Cummins & Swain, 1986). Non-native speakers schooled in a second language for part or all of the day, typically do reasonably well in early years: from fourth grade. However, when academic and cognitive demands of the curriculum increase rapidly, students with little or no academic and cognitive development in their first language fail to maintain positive gains. Canadian Inuit students taught in English reach only Grade 4 level after 9 years of schooling (Wright & Taylor, 1995; Wright, Taylor & Macarthur, 2000) and English is the greatest barrier to successful classroom learning for Aboriginal children in Australia (Zeegers, Muir & Lin, 2003).

Studies by Baker (1993) showed that learners using English as a second language and not their first language (mother tongue) as a medium of learning lag behind their peers, who are taught in first language, in areas such as mathematics and science. According to him, their second language skills are insufficiently developed to enable them to think mathematically and scientifically in their second language. By using a second language from too early on, the practices are stunting the development of the learners' own language, impeding the development of their cognitive and academic abilities, promoting negative attitudes towards the first language, and resulting in low achievement in high conceptual demand subjects such as science and mathematics. Segalowitz (1977) points out S&M subjects are inherently more difficult for most learners, even studied through their first language (mother tongue). They are cognitively high demanding and require learning tasks that involve abstract and formal thought. Many students already found S&M learning in their first language (mother tongue) inherently difficult. It would be significantly more difficult for students learning them through the second language (English), especially at a very early stage. If forced to do so, the consequence can be disastrous for those who could not cope with it. Cummins (1984) observes that most children characterized as learning disabled or learning disordered encounter language and academic problems, which are usually confined to context-reduced cognitively demanding situation.

As Alvarez (1991) observed in the Philippines, ‘English is a poor substitute for an indigenous language which is used by a child in and outside the school environment. The upper 10-15% educated and intellectual group will be able to handle and be competent in the two languages. But the greater bulk of the population will need scientific information that is popularized using the native language’. A student can master a second or a third language over the years of schooling, but the time period required varies and depends on the individual’s ability and effort. Only a small percentage of students, most of who are from the upper or middle class with strong background support, can master a second or third language at the early phases. The rest requires a much longer time to master a second language, but many of them are not successful at all during their entire schooling period. Such a form of education is selective & elitist, with high dropout rates, resulting in a generation of semi-illiterates in both the first and second language.

“The Irish findings relating to the teaching of other subjects through the medium of a second language are particularly discouraging. For it seems that the teaching of mathematics, at least through the medium of the second language does not benefit the second language, while it has a detrimental effect on children’s progress in mathematics” (Macnamara, 1966). In South Africa, the practices of using a second language (English) from too early on are stunning the development of the learners’ first language or mother tongues, impeding the development of their cognitive and academic abilities, promoting negative attitudes towards the first language, and resulting in low achievement in high conceptual demand subjects such as S&M (Saville-Troike, 1991). The abrupt switch from the mother tongue to a European language as the medium of learning in Africa has resulted in high failure rates and dropouts (Lanham 1978; Musker 1993; Alexander 1997; Hartshorne 1995).

In Peninsular Malaysia, five years after schools began teaching of science and mathematics in English schools, Ishak *et. al* (2009) tested five thousands over students from a mix of urban, rural and vernacular schools on mathematics, science and English language. The tests were made up of modified past-year public examination questions. Some were taken straight out of textbooks. The results revealed poor scores in these subjects. For example, some 1,700 year five primary school students had a mean score of 7.89 out of a maximum 20 for mathematics, a mean of 4.08 out of 14 in science, and a mean of 11.87 out of 31 for English. The study showed that the majority of students still find it hard to follow mathematics and science lessons in English. A number of local survey studies (Lim & Wun, 2003; Lim & Chee, 2005; Hamidah *et al*., 2005; Tan, 2006; Lim, Fatimah & Tang, 2007) revealed similar perceptions among the teachers themselves, and that most of the current primary and secondary S&M school teachers had only minimal proficiency in English and their lack of command of English hinders their ability to teach S&M effectively in English. The situation in the premier or elitist schools is much better, though. In rural schools, the majority of the students have no supporting English language learning backgrounds and most of them are only learning ABC formally at the entry level of schooling.

Taken together, all these are indicative of the destructive nature of a poor mastery of the language medium if that language is used as medium of instruction. As a result, children who lack the linguistic skills, but are otherwise intelligent and scholastically capable, may not be able to realize their full academic potential. Baker (1993) attributes the low academic achievement among minority children in USA and the UK to their poor mastery of English.

Jeffcoate (1984) maintains that minority pupils from working-class parentage do not enjoy equal opportunities in education due to their lack of competence in the language medium, which affects their educational attainment. Brint (1998) is of the view that children cannot learn unless their basic language skills are adequate.

The strength of utilizing student's fluency in their own language to the fullest in the formative years of education lies in enhancing student self-esteems, and motivating them towards establishing the habit of academic success since the students will perceive that their home and community culture, parents and relations are accepted by the mainstream school culture, thus minimising cultural shock (Gudschinsky, cited in Cohen, 1978). As a UNESCO document puts it:

> "Psychologically, it is a system of meaningful signs that in his mind works automatically for expression and understanding. Sociologically, it is a means of identification among members of the community to which he belongs. Educationally, he learns more quickly through it than through an unfamiliar linguistic medium" (cited in Todd, 1983:165)
>
> Otherwise, the home language & culture may seem disparaged. In these circumstances, the students will find schooling emotionally stressful and hence, vulnerable to the loss of self-esteem and status. This, in turn, may affect the child's motivation and interest in schoolwork and thereby affect performance (Baker, 1993).

THE WAY FORWARD

What constitutes the best way to assist students to learn ESL is hotly debated. There is probably no one best way to teach ESL to learners. Different approaches are necessary because of the great diversity of conditions faced by schools and the varying experiences of ESL learners with literacy and schooling in their first language (August & Hakuta, 1997). It is important to understand the consequences of various program designs for students learning English. Collier (1995) asserted that it is a mistake to believe that the first thing students must learn is English, thus isolating the language from a broad complex of other issues. In particular, one must be aware of the culturally Western-oriented tradition of S&M teaching-learning, which is loaded heavily with culturally-biased, notably towards English technical and non-technical terms or phrases. For students whose first language is not English to learn S&M successfully, they need to mediate or negotiate cultural borders, i.e. move back and forth between the indigenous and the English "scientific" culture (Jegede & Aikenhead, 1999). The teachers' role is to help the students to deal with the cultural conflicts that might arise when a student "crosses cultural and linguistic borders" from the use of the first language to English.

Research in English language learning showed that context embedded basic interpersonal communicative skill (BICS) in English can be easily acquired within two years (Cummins, 1979). BICS involves context-embedded and cognitively undemanding face-to-face communicative skills, which includes the ability to handle complex conversation using contextual cues such as paralinguistic feedback from other speakers (e.g., gestures and intonation) and situational cues to meaning (Ovando & Collier, 1985). In contrast to BICS, a period of seven to eight years is needed to acquire the cognitive-academic language proficiency (CALP) of a certain language (Cummins, 1979). CALP involves the use of language that is context-reduced and highly demanding cognitively (Ovando & Collier, 1985). It also includes academic tasks in abstract thought and formal written language. Context reduced communication relies heavily on linguistic cues alone and involves abstract thinking.

Many studies support a balanced literacy program as appropriate for students whose first language is not English to learn the English language and subject matter such as S&M. Various approaches may be used to achieve this aspiration. Both cognitive development and academic development in the first language have been found to have positive effects on second-language learning (Bialystock, 1991; Collier, 1989, 1992; Garcia, 1994; Genessee, 1987, 1994; Thomas & Collier, 1997; 2000). Moreover, literacy skills related to decoding tasks of reading have been found to transfer between languages (Bialystock, 1991; Goodman, Goodman, & Flores, 1979; Hudelson, 1987; Mace-Matluck, 1982). Specifically, learning to read and write in the first language supports success with reading and writing in the second language (August & Hakuta, 1997; Cuevas, 1997; Roberts, 1994).

The most reasonable strategy is to continue the practice of learning S&M subject matters in the student's most proficient language while simultaneously assisting the learner to acquire basic proficiency (CALP) in the second language so as to use it to learn STM and other subject matters, *if and when necessary*. Using English to teach STM subjects at an early stage will only work with students from English-speaking background or who have background and family support, especially the high ability students. Special programs may be set to cater to the needs of these students but this practice will risk creating elitism in the school. What we need is to up-grade the teaching of English as a second language in the schools, and certainly not to complicate the issue by implementing the teaching of S&M in English to all students, especially at an early stage. Given this scenario, the Malaysian Ministry of Education's reversal of the policy of teaching S&M in English, particularly at the primary school level is a positive move that should be lauded.

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LEARNING STYLE PREFERENCES AS PREDICTOR OF PERFORMANCE IN SCIENCE IN PUBLIC JUNIOR SECONDARY SCHOOLS IN GHANA

Thomas Young Tachie

Department of Science Education.

University of Education,

Winneba, Ghana.

tachieyoung2001@yahoo.com

ABSTRACT

Despite the groundswell of literature on learning styles and academic performance, little research has been carried out on learning styles in Ghana. This study examines the learning style preferences of students in the public Junior High Schools and their influence on students' performance in science. An exploratory survey was conducted using two instruments, Tachie-Young Learning Styles and Performance in Science Test. A sample of 1334 JHS students responded to the survey. The Statistical Package of Social Sciences (SPSS) was used in the analysis of data input. Data were statistically analysed using descriptive, correlation statistics, and multiple regression techniques. The dominant learning style preference of students in the JHS is auditory (65%), kinesthetic (25%) and visual (10%). Female students were more auditory in their learning style preferences than male students while the male students were more visual in their learning style preferences than the female. Jointly, 12.7% of the variance in performance is accounted for by grade level, age, sex, and auditory learning styles of students. The dominance of auditory style preference in the present study could be attributed to cultural influences where much is learned by auditory means at home and further perpetuated by traditional teaching practices.

Keywords *: Learning styles, Junior High School (JHS), JHS2&3 students (grade 8 and 9 students), Basic Education Certificate Examination (BECE).*

INTRODUCTION

Scientific experiences in Junior High Schools in Ghana are expected to cultivate in students an interest and love for science that will urge some of them to seek further studies in science as preparation for careers in science (Ministry of Education, Science and Sports, 2007). However, science teaching in the JHS has been characterised by negative features that have the potential of driving off many students. Teachers of science at the JHS, oftentimes expressed concern that even though they are teaching according to the dictates of the syllabus, they are unable to significantly impact on students' performance in their final Basic Education Certificate Examination (BECE). The general observation is that students' performance had been poor and quite a number would wish to stay out of science classes. At the national level, over 40% of the students could not make a passing grade (1-5) required for admission into second cycle institutions. At the international level, Ghanaian students' maiden participation in Trends in International Mathematics and Science Study (TIMSS) in 2003 was abysmally poor (Anamuah-Mensah, Asabere-Ameyaw & Mereku, 2004). This performance placed Ghana at the 45th position out of the 46 participating countries in the study in 2003. Ghana's performance which did not change in 2007. The general poor trend in the performance of students, especially in science, continues to be of concern to educators in Ghana.

The question is: why would students not do well if the teachers pride themselves to have adequately prepared students as well as taught the subject content to make students succeed? If teachers find appropriate ways of helping students, then students will gain confidence, be motivated to create, and express themselves (Rosenfeld & Rosenfeld, 2007). There is therefore the need for teachers to look at other factors that contribute to students' performance. Learning styles preferences of students could be one significant factor that teachers need not overlook. Whatever are the merits or demerits of learning styles they eluded the Ghanaian academic community, which this study sought to explore.

LITERATURE REVIEW

Since the emergence of learning style research around 1892, majority of the research appeared in the 1940s (Keefe, 1987). By 2006, over 650 books had been published, 4,500 articles written in professional publications and over 26,000 websites available for measuring and addressing learning styles (Howles, 2008). Learning style is basically, the preferred way to learn and the way a person learns best. Merriam and Caffarella (1991) defined it as an individual's characteristic way of processing information, feeling, and behaving in learning situations. James and Gardner (1995) defined learning style as the complex manner in which, and conditions under which, learners most efficiently and most effectively perceive, process, store, and recall what they are attempting to learn. Learning styles, as defined by Guild (1994), are conceptual, behavioural, cognitive, and affective patterns that are displayed over time and task. Students therefore possess certain basic characteristics that serve as indicators of how they learn. For the purpose of this study, three sensory learning styles, auditory, visual and kinesthetic are examined.

AUDITORY STYLE PREFERENCES

Students with auditory style preference learn best by hearing and remembering information they hear. They are distracted easily, either by noise or music. These individuals talk to self aloud and actively participate in class discussions and would prefer to tape and then listen to lectures. To recall information, they use mnemonic devices. They enjoy listening, but cannot wait to have a chance to talk themselves. These students respond well to lecture and discussion (Barbe, 1979). Often they find themselves talking to those around them. In a class setting when the teacher is not asking questions, they must find a way to express their emotions verbally (Cuyamaca College, 2004). Out of school too, they remember things said to them and make the information their own. They may even carry on mental dialogues and determine how to continue by thinking back on the words of others.

VISUAL LEARNING STYLE PREFERENCES

Students with visual learning styles learn by seeing. They think in pictures and have vivid imaginations. They have greater recall of concepts that are presented visually (Barbe, 1979). Pictures and images help them understand ideas and information better than explanations. A drawing may help more than a discussion about the same. When someone explains something to them, they may create a mental picture of what the person talking describes. They prefer to watch a speaker talk, as well as listen to what is said and are able to work from the general to the specific. They like to receive information from many sources when learning new concepts. They see the "big picture", (the forest) before seeing its part (the trees) and like to "see" things to understand them. They find verbal instructions difficult as their mind tends to wander during lectures. They like to read, and generally are good at spelling. They doodle frequently but organize well. They have good handwriting and take notice of details.

Kinesthetic Learning Style Preferences

Kinesthetic describes a learning style which involves the stimulation of nerves in the body's muscles, joints and tendons. Kinesthetics try things out, touch, feel, and manipulate. They express their feelings physically (Stronck, 1980). They gesture when speaking; they are poor listeners, and lose interest in long speeches. These students learn best by doing. They need direct involvement in what they are learning. More than thirty percent of students may have a kinesthetic/tactile preference for learning (Barbe, 1979). Often, they do not thrive in traditional schools because most classrooms do not offer enough opportunity to movement or touching. Most assessments group kinesthetic and tactile styles together, though they mean different things. Their similarity is that both types perceive information through nerve ends in the skin, as well as organs through muscles, tendons, and joints. Kinesthetics are usually well coordinated with a strong sense of timing and body movements. In some cases, they often wiggle, tap their feet, or move their legs when they sit. Some of these children were often labeled as hyperactive before this learning style was discovered (Dominican University of California, 2008).

Learning Style Preferences and Performance in Science

Learning styles have been found to have a positive relationship with academic performance, as measured by grade point average (Torres & Cano, 1994). A research conducted by Dawson-Brew (2000), among 75 undergraduate students at the University of Cape Coast, Ghana, found that 30(39%) of the students possess field-dependent learning style preferences, 22(29%) possess field independent and 25(32%) as having a combination of the two learning style preferences. Significant differences in performance of students were found among the three levels of preferences in a pre- and post-test scores. The findings, though, lend credence to the existence of learning styles preferences among Ghanaian students does not extend to students in Junior High Schools in Ghana.

Dauve, Garton and Thompson (1999) investigated if ACT, high school core grade point average, and high school class rank were predictors of academic performance and degree completion at the University of Missouri. Field-independent learners exhibited a tendency for greater academic performance than their field-dependent peers. The best predictor of students' academic performance, as determined by cumulative college GPA, was their high school core GPA. Learning style was not a predictor of students' cumulative GPA.

Park (2000) found that among Southeast Asian students there is no statistically significant difference among high-, middle-, and low achieving group in their favourable preferences for learning styles such as auditory, visual, kinesthetic or tactile learning styles. These Southeast Asian students show either major or minor preference for group learning compared with East Asian students (Koreans and Chinese) who showed negative preference for group learning (Park 1997). However, the subjects of Park (2000) study were Southeast Asians immigrants: Cambodians, Hmong, Lao and Vietnamese whose profile is different from the Ghanaian JHS students under study.

Influence of Culture on Learning Styles

Culture as a commonality of customs and rules shared by a certain group of people sets a complex framework for learning and development (Trommsdorf & Dasen, 2001). Also the systematic differences found in the way in which classrooms function in different parts of the world can be largely linked to cultural differences (Crahay, 1999). These then draw a firmer connection between culture and classroom practices. Lattuca (2002) contends that learning cannot be separated from the contexts in which it occurs, and that cognition and learning are activities that occur through social interaction. This socio-cultural view also gives equal weight to the influence of both the immediate setting as well as to the larger one in which it is embedded shifting the focus away from the individual and allowing for a multi-dimensional view of learning. These imply that there may indeed be culturally related differences in the learning style preferences of Junior High School students in Ghana as compared to either Western or Asian countries.

Influence of Age and Sex on Learning Styles.
Perceptually, the younger the children, the more kinesthetic they are and in elementary school, less than 12 % are auditory and 40 % are visual (Dunn &Dunn, 1992, 1993; Dunn, Dunn & Perrin, 1994). The older the children become the more visual and auditory they become. Additionally, they reported that as a group, females are more auditory than males; males are more visual and remain more kinesthetic than females. However, Cook (2000) examined the learning styles of freshmen entering college and their first year academic achievement. Though considerable diversity was found among four learning styles of the students, gender across the distribution of the four learning styles was quite similar. There was no significant interaction between learning style type and gender. The four learning styles were accommodator, diverger, converger and assimilator. The current study however investigates auditory, visual and kinesthetic learning styles of Ghanaian students.

METHODOLOGY

Subjects
The population of the study was all Junior High School students in public schools in the Greater Accra Region of Ghana, comprising 919 public JHSs and 151,333 students. A three-stage cluster sampling procedure was used to select the study sample of (n= 1334) students made up of 992 JHS2 students of which 471 were males and 521 females. The JHS3 students were 893 of which 428 were males and 465 females. The average age of students was 16 years. Students were drawn from diverse spectrum of socio-economic background.

Instrument
For this study the Tachie-Young Learning Styles Instrument (TYLS) based on VAK (an acronym for Visual, Auditory and Kinesthetic) inventory developed by Neil Fleming (1997) is chosen as it assesses basic characteristics of relatively young learners. Items are based on how learners use their senses of sight, hearing and touch. Auditory, visual and kinesthetic learning styles are seen as avenues of preferred perception (Eiszler, 1983) are concepts that could easily be explained through daily life experiences by students themselves and by teachers. The instrument has same dimensions as the Swassing-Barbe Modality Index which categorizes learners as preferring visual, auditory, or tactile/kinesthetic styles (Barbe & Swassing, 1979). Items of the TYLS instrument directly relate to the type of academic prerequisites and instructional activities typically assigned in classes which involve students' perception and processing of information. For example, the following statement "I find it easiest to learn something new by": listening to someone explain, watching a demonstration or trying it myself, allows for a direct connection with their ability to either listen, visualize or practise.

Face and content validity of the instruments were enhanced through assessment provided by a Professor in science education and three PhD students who were familiar with the purpose of the survey. They examined the items of the survey and were satisfied that they were representative samples of learning behaviour that was under investigation. Suskie (2007) contends that because all sensory modality instruments address sensory perceptions, they make intuitive sense and have high face validity. As a result of the review, language was moderated to suit the level of JHS students. Respondents were free to ask questions for clarifications. They were assured anonymity which presumably made them answer the items on the instrument with honesty. These measures were adopted to ensure that reliable and valid data were obtained.

The TYLS instrument is self-administered and comprises of 20 items that are designed to identify three major learning styles: auditory, visual and kinesthetic. Each item has three alternatives (A, B, or C) which describes a characteristic corresponding to each of the three styles. The dominant learning style of an individual is determined by adding up the number of As, Bs or Cs one selects. As refer to Auditory, Bs to Visual and Cs to Kinesthetic. Students were required to award marks out of 10 to each of the preferences. The scores indicate rating of a student's preference. For example, a tick (√) or circling of B would indicate an inclination for visual learning. Awarding marks out of 10 to each alternative indicates how much one prefers one option over the other(s). An example is shown in Table 1 below.

Table1: Illustration of scoring of items on the TYLS
In my free time, I would rather prefer to:

A	**talk with a friend**	**3**
B√	**watch cartoons on TV**	**6**
C	**move about and play**	**1**
		10

The second instrument, Performance in Science Test (PiST), made up of 46 items examined common themes. Some of these were on matter, living things, energy, water, soil, solar system and measurement. Internal consistency estimates of reliability gave a Cronbach's alpha values of 0.53 for Auditory, 0.46 for Visual, 0.43 for Kinesthetic. This compared to 0.41, 0.53, 0.54, and 0.55 determined by Van Zwanenberg et al., (2000) for a sequential-global dimension for measuring learning style preferences of students using the Index of Learning Styles (ILS) instrument. The Performance in Science Test (PiST) Scale had Cronbach's alpha value of 0.82. Tuckman's (1999) suggests that an alpha of 0.75 or greater is acceptable for instruments that measure achievement and .5 or greater is acceptable for attitude tests while Duvall (2008) also asserts that a reliability of 0.70 or better is desirable for classroom tests.

Procedure
The Tachie-Young Learning Styles Instrument (TYLS) and the Performance in Science Test (PiST) were administered to participants in each of the selected schools. All the JHS2&3 students present on the day of the visit took part in the exercise. Instructions on the questionnaires were simple but time was made available to explain the procedure of scoring to the participants.

RESULTS

Learning style preferences of students
The students' dominant preferences were 772(65%) kinesthetic 302(25%) and 114(10%) for visual. Figures1 and 2 show distribution of students' learning styles and multimodality of individual student's styles respectively.

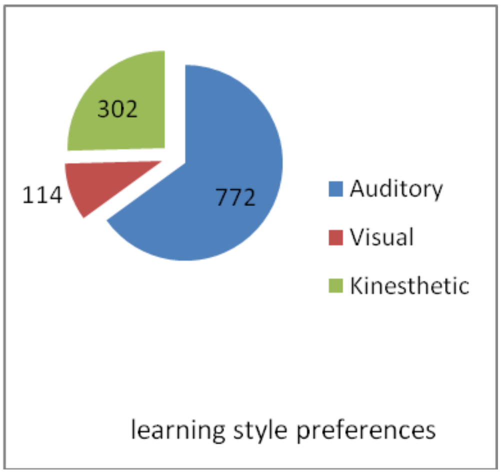

Figure 1: Distribution of students' learning styles

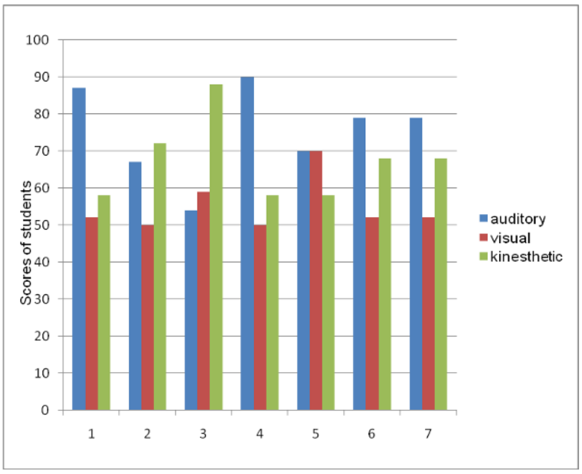

Fig. 2: Multimodality of individual students' styles

Students were more auditory in their style preferences and were neither exclusively, auditory, visual nor kinesthetic in their learning styles. Correlation between each pair of learning style preferences (Table 2) was moderately negative; when one learning style increases the other decreases. For example, the correlation between auditory and kinesthetic showed a negative correlation, *(r =0-.566)* that was statistically significant, meaning increased auditory lowers (decreases) kinesthetic styles of the individual student.

Table 2: Pearson's Correlation among Auditory, Visual and Kinesthetic Learning Styles

	Auditory	Visual	Kinesthetic
Auditory	**1**	**-.472***	**-.566***
Visual	**-.472***	**1**	**-.265***
Kinesthetic	**-.566***	**-.265***	**1**

* Correlation is significant at the 0.05 level (2-tailed).

Learning style and performance in science

Using multiple regression techniques, results show that from the three predictor variables (auditory, visual and kinesthetic) the effect on performance in science is significant for only auditory *F(1, N = 1153) = 11.530, p=.001*. The coefficient of determination R^2 *(.010)*, indicates that about 1.0% of the variance in the science score is predicted by the predictor variable, auditory. Figure 3 shows a graphical relationship between the learning style preferences and performance in science of first seven individuals of the study.

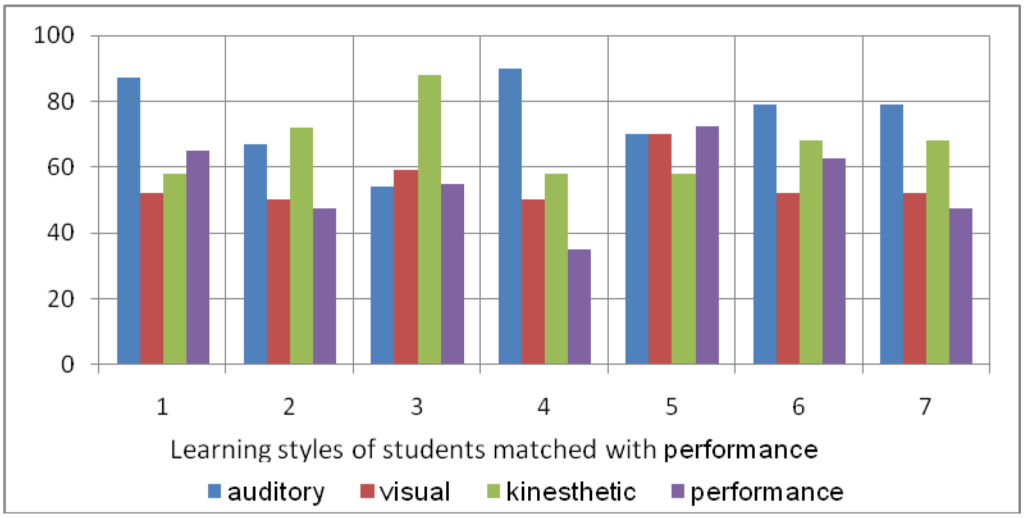

Figure 3: Graph showing learning style preferences and performance in science

Age, Sex and Grade Level on Learning Styles

The variable that significantly affects auditory and visual learning style preferences is sex whereas grade level and age significantly affect kinesthetic learning style preferences. Female students were more auditory in their learning style preferences (M = 77.65, SD = 14.70) than the male students (M = 75.81, SD = 15.77), $t(1184) = -2.08$, $p = .038$. The male students were more visual in their learning style preferences (M = 56.71, SD = 11.60) than the female students (M = 54.69, SD = 11.96), $t(1182) = -2.94$, $p = .003$. With regards to performance, results indicate that 12.7% of the variance in performance is accounted for jointly by grade level, age, sex, and auditory learning style of students. Auditory learning style preferences contribute 0.6% of the variance in performance, students' sex, age and grade level contribute 1.2%, 4.5% and 6.4% respectively. The male students' performance was better than that of the females, the JHS3 students' performance was better than that of the JHS2 but there was no significant difference between the performance of the age categories.

DISCUSSION

Learning Style Preferences of Students

JHS students were found to be more auditory in their learning style preferences than visual or kinesthetic. The dominant preference was auditory, 772(65%), kinesthetic 302(25%) and visual 114(10%). Comparing findings to the work of Brown & Cooper (1976), students of the Manatee Community College in Bradenton, Florida, (USA) were found to be 65% visual, 22% kinesthetic and 13% auditory. Apart from the kinesthetics who were comparatively near to each other, the auditory and visuals were directly opposite: the Ghanaian students were 65% auditory while the students in Florida were 65% visual. In high school grades 7^{th}, 8^{th}, and 9^{th}, in Cordoba, Sucre, Atlantico and Bolivar, Colombia, kinesthetic style was the most prevalent followed by tactile, auditory and then visual style (Juris, Ramos & Guadalupe, 2009). However, Aguirre, Cancino and Neira cited by Juris, et. al (2009) found that the auditory learning style was the most representative in a group from the National University in Bolgota. In East Asia, Korean, Chinese and Japanese students were all found to be visual learners, with Korean students ranking the strongest (Reid, 1987).

Considering the Ghanaian situation, the JHS students might thus be auditory learners because of their environmental upbringing. Most traditional Ghanaian homes expect children to exercise ‘obedience to authority’. Children are told: “listen to what I am saying” and if the child shows attention by looking directly into the face of the person, the child is rebuked “why are you looking at me like that”. It is a sign of disrespect if a child looks directly into the face of the one speaking to him or her. The child must “hear” not “see”. This practice has made children grow into adults who do not look directly in the face of persons speaking to them. At home children do not have much opportunity to ask the “why” “how” and “where” of things. They have little or no opportunity to educational materials to build upon their visual and kinesthetic experiences. Such practices of the home on behaviour, thinking and practice are likely influences on students being mostly “listeners” than “visualisers” or “doers”. This view is supported by the assertion that a learner’s style is a response to stimuli in the environment and with the types of tasks and problems the learner faces therein (Kolb, 1994, Sadler-Smith, Allison & Hayes, 2000).

Multimodal learning styles of JHS students

All the students (100%) had multimodal learning styles. Gilbert and Swanier (2008) assert that learning preferences facilitate the way individuals learn when the environment provides a variety of learning styles. The JHS students might be facing challenges while doing well the auditory way but perhaps not “stimulated” adequately to learn in other ways. Stevenson and Dunn (2001) suggest that many students can master easy information in the "wrong" learning preference for them, but they can learn more efficiently and rapidly when they use their own learning preference. Students would normally prefer to learn in a variety of ways, with each style of learning having its own unique strengths and weaknesses (Cook, 2000). Such multifariousness in learning styles suggests that it is important for teachers to consider this diversity in order to more fully harness each student’s learning potential (Kaplan & Kies, 1995; Wallace, 1995). If JHS students are not performing it also might be because of excessive auditory environment provided by schools and home. However, it is likely that they might perform better if they are exposed more to other learning styles preferences.

Sex on Auditory and Visual Preferences of Students

The study found that female students in the study were more auditory in their learning style preferences than their male counterparts while the male students were more visual than the females. These findings support views that as a group, females are more auditory than males and males are more visual and remain more kinesthetic than females (Dunn & Dunn, 1992, 1993; Dunn, Dunn, & Perrin, 1994). Brown (2007) reporting on the work of Diane Connell, a professor of New Hampshire's Rivier College said that “girls' left brain (responsible for speech discrimination) tends to develop more quickly than boys' left brain”. They (girls) are able to hear better. Boys' right brains - responsible for spatial and visual motor skills-develop faster than girls', so they do better in mathematics and prefer hands-on activities. In a similar report by Sax (2005), girls are shown to be born with a sense of hearing significantly more sensitive than boys, particularly at the higher frequencies most important for speech discrimination. Those differences grow larger as kids get older. Scientists have found that the girl can hear sounds much softer than the faintest sounds audible to the boy (Sax, 2005). These findings explain the higher auditory preferences of girls over boys and boys’ visual preferences over girls.

Learning styles, as indicated in the introductory chapter of this paper, might not be panacea for poor performance and neither could any one-to-one variable such as the home, the school nor the teacher be. What matters, however is the teacher’s ability in using the knowledge of these seemingly insignificant variables to enhance the adjustment of the learner to the learning situation. Students themselves need the awareness of their styles to encourage them take more responsibility for their learning (Felder & Brent, 2005).

Learning Styles and Personal Characteristics of Students and Performance

Findings show that learning styles and selected students’ characteristics, namely, age, sex, grade level, collectively contributed 12.7% to the variance in performance. The variance contributed by each of these significant variables (auditory 0.6%, sex, 1.2%, age 4.5% and grade level 6.4%) suggest that performance is not necessarily determined by any one-to-one variable. From among the three learning styles, only auditory preferences significantly contributed (0.6%) to the variance in performance which possibly was influenced by cultural practices and teachers' style (though not investigated).

With regard to better performance of boys over girls in science, stereotypes associating science with males than females across nations could have significant influences on variances in performance (University of Virginia, 2009). Males perform better than females in mathematics and science and the gap widens (and becomes statistically significant) by age thirteen and persists through secondary schooling (Dee, 2007). The magnitude of the gender gap in science achievement remains similar from fourth to twelfth grade (University of Virginia, 2009). Since this study has also indicated better performance of boys over girls it should be a matter of concern for science teachers. Teachers as the most causal factor in defining the quality of education in schools could design teaching sequences that could make learning of science meaningful for girls in order to bridge the widening gender gap.

Conclusion

Learning styles, specifically auditory, explained only (0.6%) of the variance in performance. However small the variance found in this study, it counts as it jointly with age, sex and grade level contributed to a greater variance of 12.7% in performance. Learning from learning styles could therefore be a variable of improving performance of the Ghanaian child in school science. It would require teachers to initiate processes that expose students to active participation in activities (doing) and provide equal or more opportunities also to "seeing" than "hearing."

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A TEACHING UNIT ON LIQUID CRYSTALS

Saša Ziherl
University of Ljubljana, Faculty of Education
sasa.ziherl@pef.uni-lj.si

Jerneja Pavlin
University of Ljubljana, Faculty of Education
jerneja.pavlin@pef.uni-lj.si

Katarina Susman
University of Ljubljana, Faculty of Education
katarina.susman@pef.uni-lj.si

Saša A. Glažar
University of Ljubljana, Faculty of Education
sasa.glazar@pef.uni-lj.si

Mojca Čepič
University of Ljubljana, Faculty of Education
mojca.cepic@pef.uni-lj.si

Nataša Vaupotič
University of Maribor, Faculty of Natural Sciences and Mathematics
natasa.vaupotic@uni-mb.si

ABSTRACT

Although liquid crystals can be found in several everyday devices, people know little or even nothing about them. In this contribution we present a teaching unit on these novel materials. Since the topic is very interesting, the unit can also be used to increase public motivation in science. The aims of the unit are: to teach students what liquid crystals are, to introduce students an additional phase and to show special optical properties on which liquid crystal display (LCD) technology is built. The teaching unit was tested among the first year undergraduate students of physics education. We present the results of the pilot evaluation of the knowledge gained by the unit.

Keywords: *liquid crystals, teaching unit, pedagogical survey*

INTRODUCTION

The development of modern science and technology brought liquid crystals (LCs) into everyday life. Many people are aware that liquid crystals are present in displays, phones, laptops… But they rarely know that liquid crystals also exist in natural systems such as biological membranes, cell membranes, DNA, silk and even in some skeletons of bugs… (Vilfan *et al.*, 2002; Brown *et al.*, 1983; Wright 1973). Technologically they are used in systems where fast response is needed. Despite the fact that LCs are quite common, youngsters have very limited knowledge about them. This was shown by the study on conceptions about the liquid crystals performed on the secondary school pupils' (Pavlin *et al.*, 2010). Although we were aware of the minute knowledge about liquid crystals in a general population, the results of the study additionally inspired us to design a teaching unit on these complex materials. The unit presented in this paper was prepared for the first year undergraduate students, who enrolled to the study program of physics education. This study program is designed for future teachers of Physics in the elementary (age 13 - 14) and secondary schools, except gymnasiums (age 15 - 18). In preparing the unit we took into account that the students have the unit in the first semester of the first year study at the university. So their knowledge of Physics is very limited since some of the students come from the secondary schools where they had no Physics course. Because of that the unit focuses on gaining qualitative understanding of the basic properties of the liquid crystalline phase.

THEORETICAL BACKGROUND

The teaching unit is composed from a lecture in duration of 90 minutes and a practical laboratory work of the same duration. The lecture explains basics about the liquid crystals as materials having a peculiar phase between the commonly known isotropic liquid and crystalline state. Then the lecture introduces the optical properties of liquid crystals and the technology of LC displays.

The laboratory work starts by students observing the three phases of liquid crystals. They measure two transition temperatures: the phase transition temperature between the crystalline and the liquid crystalline phase and the phase transition temperature between the liquid crystalline and the isotropic liquid phase. Liquid crystals are closed in a glass tube and they are in the crystalline phase at the beginning of the experiment. Students put the tube into the water bath and heat the water. They measure the temperature of the water which is assumed to be the approximate temperature of the liquid crystals in the tube. They first observe the transition between the crystalline and the liquid crystalline phase and measure the transition temperature. After a while, the transition between the liquid crystalline phase and the liquid phase can be observed and they measure this transition temperature as well. They observe and write down the differences of the appearance of the material in all three temperature regions (Figure 1, 2).

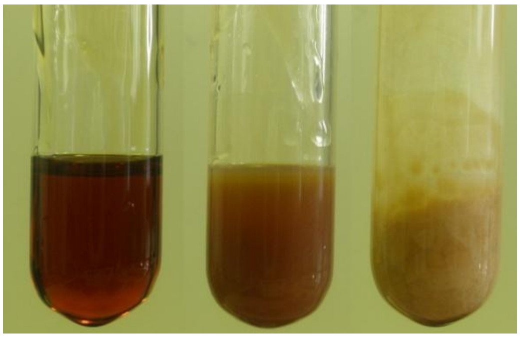

Figure 1: Liquid (left), liquid crystalline (middle) and solid (right) phase of MBBA.

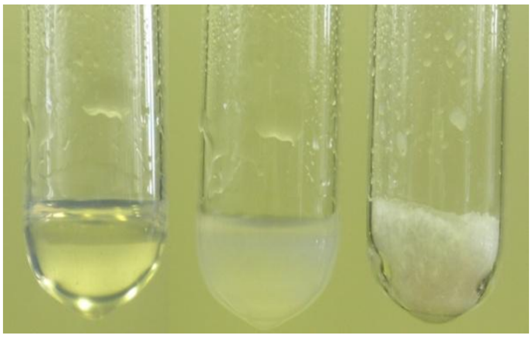

Figure 2: Liquid (left), liquid crystalline (middle) and solid (right) phase of cholesteryl benzoate.

Our students use two different liquid crystalline materials: MBBA (Figure 3) and cholesteryl benzoate (Figure 4). While students work in the laboratory, especially with liquid crystals mentioned above, they have to take into account safety precautions: they must wear safety goggles, lab coat and gloves. The first liquid crystal they handle with is cholesteryl benzoate which was the first material in which liquid crystal properties were discovered. In the late 1880s Friedrich Reinitzer, an Austrian botanist, while studying the chemicals in plants, heated cholesteryl benzoate. At 145 °C the material melted, yielding a cloudy fluid, which changed to the originally expected clear liquid at 178.5 °C. In 1888, the German physicist Otto Lehmann concluded the cloudy fluid presents a new phase of matter, and coined the term liquid crystal (Verbit, 1972). MBBA (n-4'-MethoxyBenzylidene-n-ButylAnilin) is one of the most prominent examples of nematic liquid crystals. The phase transition temperatures for MBBA from the crystalline to the LC phase occur at 24°C and the phase transition to the isotropic liquid is at 41°C (Liberko, 2000). Students notice the typical difference between the isotropic liquid and the LC phase: the first one is clear whilst the LC phase is opaque. This triggers further thinking on the reason for such a difference in optical appearance.

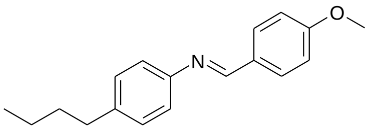

Figure 3: The skeletal formula of MBBA.

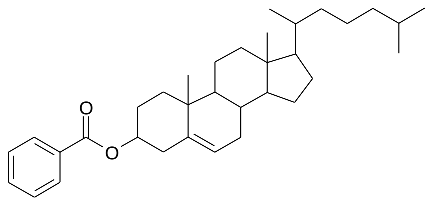

Figure 4: The skeletal formula of cholesteryl benzoate.

In the next experiment students use MBBA to make two prototype LC cells having parallel glass plates, the first cell with non-ordered liquid crystal molecules and the second with ordered molecules. The cell is made of a microscope slide, cover glass and a plastic foil. For the fabrication of the first cell students take the microscope slide and carefully set 2 layers of foil approximately 1.5 cm apart on both sides of the slide (Figure 5). They put a drop of liquid crystals on the slide, between the foil and place the cover glass on it (Figure 5, 6). For the second cell, a special kind of velvet is also needed to rub it against the slide. The fabrication procedure of this cell is similar to the procedure used by the first cell. Before putting the drop of liquid crystals on the slide, the slide is rubbed by the velvet in one direction (Figure 7). The micro notches are made on the glass. LC molecules at the surface align along these micro notches. This promotes the alignment of molecules everywhere in the thin LC layer between the microscope slide and the cover glass.

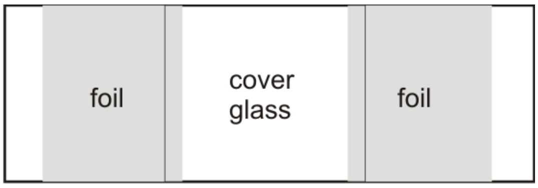

Figure 5: A sketch of a planar cell with parallel glass plates.

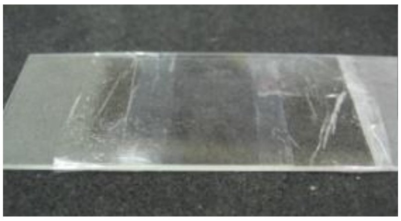

Figure 6: Planar cell

Figure 7: Rubbing the cover microscope glass by velvet in a certain direction

When the cells are prepared, students observe both of them between crossed polarisers under the school microscope (magnification: 300) and they describe the differences between these two cells (Figure 8, 9). The black line seen on the figures is a pointer of the microscope.

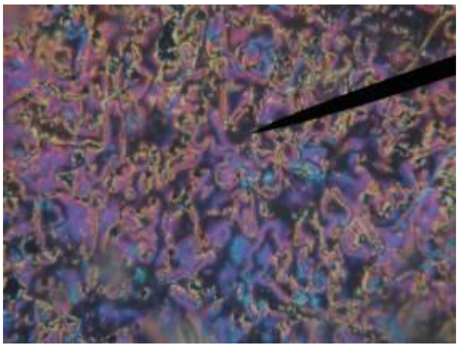

Figure 8: MBBA in a planar cell between crossed polarisers and observed under a microscope.

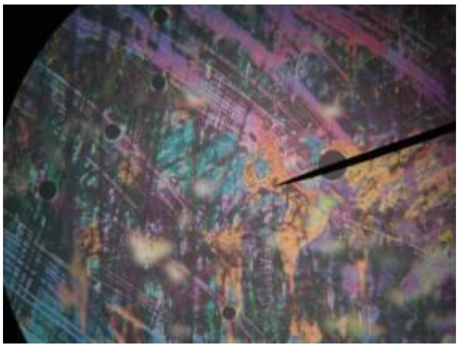

Figure 9: MBBA in a planar cell between crossed polarisers and observed under a microscope.

If one of the polarisers is turned for 90°, the colours switch to complementary colours (Figure 10).

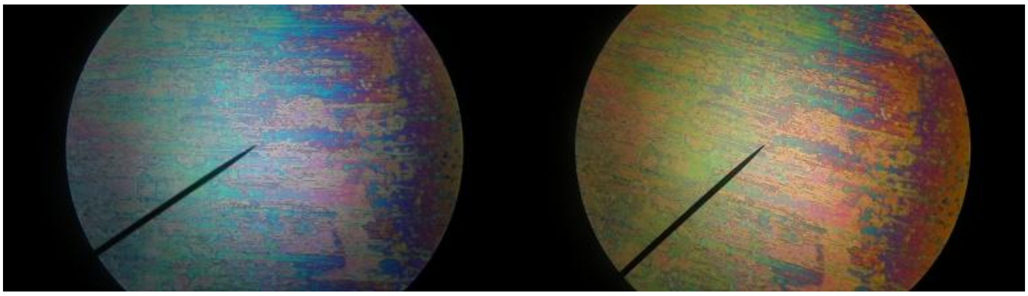

Figure 10: MBBA in a planar cell with notches, observed under a microscope when polarisers are crossed (left) and parallel (right).

It is also interesting for students to observe the liquid crystal cell under the microscope during heating the cell with a hair dryer. They can observe optical differences between the liquid crystalline phase and the liquid phase. The liquid crystalline phase is optically anisotropic and optically anisotropic materials have the capability to rotate the polarization of light. Therefore some light is transmitted when the cell is put between the crossed polarisers. When the cell is heated by a hair dryer the phase transition to the isotropic liquid occurs and one can observe disappearance of the colours. The cell observed under the microscope turns completely black.

The next step is to fabricate a wedge cell which can be used for visualization of the double refraction and the observation of mutually perpendicular polarization of the two beams. We use a wedge cell in order to obtain divergent ordinary and extraordinary beams, which are then observed on the remote screen. Students begin by carefully putting 6 layers of plastic foil on the microscope slide. Then they rub the slide with velvet in one direction. They put a drop of liquid crystal on the rubbed slide and place the cover glass on it (Figure 11). Then they shine through the cell with a laser beam and they can observe double refraction on the screen (Figure 12, 13). The following questions are posed to the students: i) Are these two beams polarized? ii) If they are polarized, what is the direction of polarization in each beam? iii) What happens to the beams if the cell is heated by the hair dryer (Figure 14)?

Students use the polarizing foil to answer the questions on polarization. They find out that the two beams (Figure 13) are polarized, polarization in one beam being perpendicular to the polarization in the other beam. When they heat the cell, one of the beams disappears. The beam which is specific for the liquid crystalline phase is called the extraordinary beam, while the beam that remains also in the isotropic phase is called the ordinary beam.

In this experiment as well as in the previous two, students used the liquid crystal sample that was produced in the school laboratory. The synthesis of the liquid crystal is another topic for another teaching unit so we shall not address it in this paper.

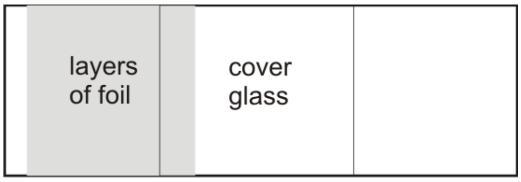

Figure 11: A sketch of a cell with wedge glass plates.

Figure 12: The experiment with a laser beam and a wedge cell.

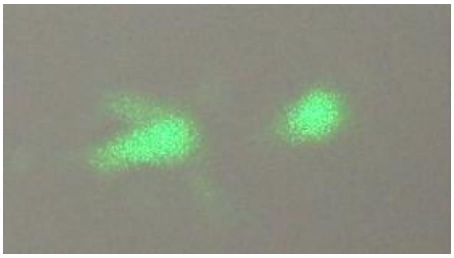

Figure 13: Double refraction in the LC phase, observed on the remote screen. Left: extraordinary beam; right: ordinary beam.

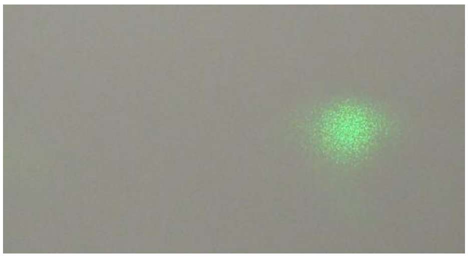

Figure 14: After heating the cell to the isotropic phase only one beam is observed.

METHODS AND RESULTS

In this pilot study we expected to obtain the answers to the following research questions:
- *How, and to what extent, does the designed unit bring knowledge about liquid crystals and their basic properties?*
- *How, and to what extent, do students gain knowledge about liquid crystals by means of the designed unit?*

The research questions are answered by means of a design research strategy. The design experiments were developed as a way of carrying out formative research, in order to test and refine educational designs based on theoretical principles as derived from the prior research. This approach of progressive refinement in design involves testing of the first version of a design in a real life to see how it works. Subsequently, the design is constantly revised based on experience, until all the 'bugs' in it are solved (Collins et al., 2004).

An objective of the design research is to make it possible to discuss and improve the effectiveness of teaching-learning strategies (Lijnse, 1995). The first design of a teaching-learning sequence or unit is based on theoretical aspects, experiences of the research group and the notions of the researcher. Once it has been designed, the development of a unit is a cyclic process of designing, testing in a real-life situation, and analysis of the collected data. The outcomes of one cycle form a basis for the second cycle. Thus the unit develops during research (Lijnse, 1995).

The analysis of the unit was done by chronological evaluation of the data obtained from testing. The testing of the unit took place in a class of 25 physics students and the first cycle of the testing of the unit was in December 2009. The testing took place in a classroom in which students could easily work in pairs. Students worked on the unit for about 95% of the estimated time. The teacher did not interfere with them during their discussions: this only took place when teacher – student interactions were planned.

The data collection took place by the classroom observations during the lectures and laboratory work, especially at the milestones with the respect to the activities of the unit, by a questionnaire filled out before the teaching took place (pre-tests), and by collecting worksheets with the students' answers (post-tests). The results of the pre test can be seen in the contribution of Pavlin *et a*l. (2010). The post test was a part of a written exam to make the students highly motivated for answering. The post test questionnaire included also some questions from the pre test, which made the evaluation more elaborated. An observer was helping with the experiments and detected the comments and discussions in the classroom. Data collection included the pre and post tests of all students and the classroom observations (field notes). The data analysis was mostly qualitative.

During the laboratory work we noticed that students were amazed over the colours they were able to observe in the LC cell under the microscope. The colours were directly connected to screens and LCD televisions. Beside colours the most interesting part was the wedge cell that caused the laser beam to split into two beams. Some students expressed the interest in the temperature dependence of the optical properties of liquid crystals as well. All comments show that students were enthusiastic about the unit and that they have never experienced a personal touch with the liquid crystals before.

Pre-tests included 17 questions of different types (Pavlin *et al*., 2010). On pre-test students on average achieved 24%. Most of the students who had heard about liquid crystals related them to displays. The pre-tests showed that students' knowledge about liquid crystals was very limited.

During the laboratory work students received the instructions for experiments on the worksheets. They followed the instructions and answered all the questions on the worksheets, more or less successfully, which was proven by the results of the analysis of the worksheets. The worksheets were scored and students on average achieved 83%. The results were quite stimulating for us. At the end of the semester students wrote the exam that included 3 questions related to liquid crystals and served as post-test. The results revealed that all of the students were able to list at least 3 products where the liquid crystals are integrated in (100%). The question connected to double refraction of liquid crystals was noticed to be well understood. The teaching unit helped students to visualize and understand the phenomenon of double refractivity as well as the role of liquid crystals (on average students achieved 70%). The last question revealed the lack of knowledge on the properties of liquid crystals that makes them special and distinguishable from other substances. Most of the students were not able to recognize the properties that are essential for the use in technology. Only 30 % answered correctly. Nevertheless if we consider the average score of the post test we can conclude that the improvement in knowledge is significant: from 24% at the pre test, to approximately 70 % at the post test.

CONCLUSION

By means of the activities in the unit on liquid crystals students were guided to gain knowledge about liquid crystals. To answer the first research question: "*How, and to what extent, does the designed unit bring knowledge about liquid crystals and their basic properties?"*, we analyzed the data which were acquired from the testing of the design unit. If we start with goals of the teaching unit, we can easily find out that the unit enables assimilation of knowledge of a new topic in physics – liquid crystals. The teaching unit presents the students a new, liquid crystalline, phase and it gives a qualitative explanation of colours and double refraction. To answer the second research question: *How, and to what* *extent, do students gain knowledge about liquid crystals by means of the designed unit?*, we take into account the data from the pre- and post-tests and detect on average a significant progress in the basic knowledge of liquid crystals, regarding their optical properties and application.

Our results show that further work on this interdisciplinary topic, which should be carefully included into the physics and chemistry curricula, is worth the effort.

The conclusions are limited, because only 25 students were involved into this pilot study. However, the result shows that it is worthwhile to follow up this design study with larger groups of students at different study programs.

Europe faces the problem of low motivation for natural science studies. Introduction of contemporary research and technological problems into science teaching makes the context of learning more motivating especially when students are actively involved. Inclusion of topics on liquid crystals into syllabus makes studying of physics more meaningful as it brings everyday life into the classroom.

ACKNOWLEDGEMENTS

The team would like to acknowledge the interest and the willingness of cooperation of the students in the first year studies of physics education in the academic year 2009/10. The work reported here was partly financed by the Ministry of Higher Education, grant No. J5-0365-0588.

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XIV IOSTE

XIV IOSTE Symposium, Bled, Slovenia, June 13. - 18. 2010
Socio-cultural and Human Values in Science and Technology Education

EXTENDED ABSTRACTS

WHY CHOOSE A TECHNICAL CAREER?

Håkan Ahlbom

University of Gävle

hanahm@hig.se

Edvard Nordlander

University of Gävle

enr@hig.se

ABSTRACT

Technology is a neglected mandatory subject in the Swedish compulsory school. The subject is supposed to inspire young people to consider a technical career, due to an increasing need for engineers and a declining recruitment to engineering education.

An investigation of influential factors for choosing a technical career is presented. The factors are well-known, but the relative impact of the factors is investigated using questionnaires and semi-structured interviews with engineering students. Special focus is put on the effect of previous technical schooling. The most important factors for choosing technical education are personal technical interest, future salary expectations, and personal qualities.

Keywords: *Impact factors, technical education, career choice, semi-structured interview.*

INTRODUCTION

Technology is a mandatory subject in the Swedish compulsory school since almost 30 years, and for the last 15 years it is a separate subject with a syllabus of its own.

The Swedish Education Act states that all children shall have equal access to education in the national school system (SFS No: 1985:1100). The municipalities are responsible for providing compulsory schooling to all children. The Swedish government is clearly stating a goal for the Technology subject to ensure pupils developing an interest in technology, as well as ability and judgment when handling technical issues (Skolverket 2000). However, the Technology subject seems to be lost in practice. This is shown by *e.g.* the governmentally commissioned Swedish Technology Delegation (Teknikdelegationen 2009). As a result of this neglect, the Swedish school system is putting the interests of public demands and society aside. This will harm the Swedish society in the long run.

Does this mean that more pupils should be inspired through the Technology subject in compulsory school to consider a technical career by means of increasing the technical interest? In a previous version of the syllabus for the Technology subject given in the national curriculum, Lpo 94, it was stated that the education in Technology also should stimulate the technical interest for both girls and boys and to facilitate their future choice of study and career.

Hence it seems so, but for some reason this part of the syllabus was deleted in a later revision. Regardless the reason for that, there is an increasing need for engineers in Sweden due to declining recruitment of engineering students during the last decade. In this paper, the relative impact of influential factors given by engineering students to choose a technical career is presented.

METHOD

The hypothesis of the investigation is that an engineering student has got a driving force towards being an engineer. This driving force is not always clear to the student, but there are several influential factors, either promoting or opposing, in the process of being an engineer. Most of the factors are well-known, but in this investigation the relative impact of the factors are given. The method used in this investigation is based on questionnaires and semi-structured interviews with 3-year engineering students at a regional, medium-sized university in Sweden. The engineering programs represented in the study are electronics, computer, mechanics, industrial economics, geomatics, and construction. In the questionnaires the student could rank the importance factors (from a given list) for attending an engineering education. The factors given in the list were chosen from literature, with justification from interviews done.

There is a specific focus from the authors on the effect of previous technical schooling as a factor, especially the mandatory Technology subject in compulsory school.

RESULTS

School subjects seem to have different influence on the choice of education. This is due to the different kinds of engineering education represented in the study. For electronics, computer and mechanical engineering students, mathematics along with physics were important factors. For industrial economics and geomatics students, mathematics along with geography and social sciences seems more important for their choice. More than one third of the students thought that none of the subjects in compulsory school had influence of their choice, but more than half of the students thought that upper secondary education influenced their choice. Taking a technical program at upper secondary school seems to be an important factor for the choice of education, and many of the engineering students come from natural science or technical programs in upper secondary school. An interesting result is that very few students considered the Technology subject in compulsory school as an important factor for choosing engineering at the university.

The most important factor for choosing a technological education was a personal technical interest, followed by future salary expectations, personal qualities, and the status of expected position. The geographical location of the education was more important as a factor than the (status of the) university itself. Next in rank came personal influence from parents, relatives, friends and other persons. In the interviews there is often a specific person, working as an engineer or otherwise involved in the technical domain, who served as role model for the student. Teachers and student counselors do not seem to have a dominant impact on the choice. None of the students thought of gender as influential on the choice of education.

The most important personal qualities for the choice of technological education were logical capability, technological literacy, curiosity and mathematical interest. Only few thought that persistence or sociability were important in this respect, and none picked political interest or artistic capability.

CONCLUSIONS

The results from the questionnaire verify that the Technology subject in compulsory school is lost in practice. The subject had virtually no impact on their decision to choose engineering.

Almost all students claim that they only took the subject in the three last years, although the national curriculum prescribes the subject in all 9 years of compulsory school. Is it really so that they didn't get any education in technology in early years, or was it integrated into other subjects? No matter what, it is obvious that the subject is failing to promote higher technical education for the students. The most influential subjects in school are mathematics together with other subjects depending on the direction of engineering taken by the student.

The most important factor is the personal technical interest. One of the goals to aim for in the syllabus for the Technology subject is *"that the pupils develop their interest in technology" (Skolverket 2000)*. If students do not consider the Technology subject as an important factor for choosing a technical education but nevertheless find themselves technically interested, where does the technical interest come from? What factors are building a technical interest more efficiently than school? Furthermore, technical literacy was considered as an important personal quality for choosing a technical education. Technical literacy is also one of the reasons for having a Technology subject in compulsory school. But if the Technology subject has no impact on technical literacy, where did it come from?

It is interesting to notice that although only one out of four Swedish engineering students are female, none of the respondents regarded gender as influential on their personal choice of education. The result may be interpreted as a problem not situated on the personal level, but rather being of another dimension. In the interviews the students explain the situation as a matter of influence from early childhood, in the different way girls and boys are treated. One student indicated that if you give traditional dolls to girls and Transformers, *i.e.,* technically advanced fantasy dolls, to boys, children are indoctrinated that technological advanced toys and technology are for boys.

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FUTURE ENGINNERS AND SUSTAINABLE DEVELOPMENT

Boris Kramberger

Fakulteta za kemijo in kemijsko tehnologijo, Smetanova 17, 2000 Maribor

boris.kramberger@uni-mb.si

Elena Aionicesei

Fakulteta za kemijo in kemijsko tehnologijo, Smetanova 17, 2000 Maribor

elena.aionicesei@uni-mb.si

Željko Knez

Fakulteta za kemijo in kemijsko tehnologijo, Smetanova 17, 2000 Maribor

zeljko.knez@uni-mb.si

ABSTRACT

The paper is based on research regarding the comprehension and involvement of undergraduate students with the principles of sustainable development (SD). The students which have taken the survey were in the last years of their engineering studies at the University of Maribor, Slovenia. They answered via questionnaire to some basic inquiries about understanding sustainable development and following its principles. The study also includes students' point of view on professors' connecting the SD principles with the topic of their lectures, together with their opinion on the collaboration between university and other institutions (state and municipal authorities, enterprises, research institutes, etc).

Keywords: *Sustainable development, engineering education.*

INTRODUCTION

The complex and evolving concept of sustainable development is differently comprehended and accepted around the world. More than twenty years passed since the concept was introduced; but its principles are continuously developing, and new ones emerge from the needs and demands of today's society. But the needs of the present generation should be met without compromising the ability of future generations to meet their own needs (IUCN, 1980). After being accepted as the concept that should guide all actions for building a better future, many organizations tried to define the principles of sustainable development. The intention was to attract and employ stakeholders into actions that support, apply and develop these principles. Universities, through there triple role – research, education and innovation – should occupy a key position in promoting sustainable development by providing students with both knowledge and skill; knowledge on how to identify and analyze the problems facing today's society and to forecast future consequences; and skills in dealing with these situations today and in the future. While many nations around the world have recognized the importance of education to build capacity to achieve sustainability, only limited progress has been made with implementing it. This lack of progress stems from many resources. One of the reasons is that the need for change is not readily apparent. Lack of or inadequate national, regional and local policy to support education for sustainable development (ESD) has also impeded progress. But probably the major obstacle is the lack of resources such as funding and trained personnel.

METHODS

To analyze the familiarity of the future engineers from the University of Maribor with sustainable development and its principles a survey was conducted. The survey comprised 28 undergraduate students from Faculty of Chemistry and Chemical Engineering and Faculty of Electrical Engineering and Computer Science. The questionnaire seeks to find out whether future engineers already heard about sustainable development, if they are familiar with its principles and if they follow them in professional and domestic environment.

RESULTS

The survey showed that only 46% of students that answered the questionnaire have already heard of sustainable development. Out of these only 7% are familiar with its principles. The questionnaire included questions on how/if the professors involve sustainable development in their lectures/exercises. Almost 40% of students answered that there is no connection between the lectures and the principles of SD. 57% consider that SD is poorly integrated in the curriculum, while only 3% think that lectures and seminaries completely involve its principles. Based on the previous question, we were interested where did future engineers hear of SD. 23% heard during their studies at the University, while 77% through media, internet and other sources. Most of them (70%) got familiar with the topic a year or two ago. As going deeper into the problem, we see that there is no collaboration between faculties and students on discussing measures of sustainable development in their institution. On the other hand more than half (63%) of the enquired students are partially aware of the impact their faculty's activity has on the environment and natural resources. The proposed and applied measures by each faculty are very poorly introduced to students. Only 11% think they are familiar with these measures while 32% are partially familiar with the actions taken by their institution. Furthermore the survey showed that 93% of students are fully or partially aware of the impact of their domestic activities on environment; 89% of them are fully or partially aware of measures that reduce this impact; and 82% apply sustainable measures in their domestic activities. Two thirds of the enquired students believe they do not have enough possibilities to learn more about SD. On the other hand 30% are interested in obtaining more information and they also propose the means of obtaining this information; they propose seminars (44%), additional lectures (22%) and conferences and workshops (34%). Based on this survey we can conclude that knowledge on SD is very limited with future engineers graduating from our University. The results show that professors and assistants do not introduce the principles and measures of SD properly or even avoid introducing them in their lectures and seminaries. This fact is concerning as work of these future engineers will have a huge impact on environment and exploitation of natural resources.

CONCLUSION

Sustainable development is hard to define and implement, and also difficult to teach. Even more challenging is the task of totally reorienting an entire education system to achieve ESD. Universities play an essential role in implementing these changes. The concept of SD and its segments – environmental, economical and social – may be easier understood at this level, and thus these changes may be easier put into practice. The main conclusion of the survey presented in this work is that most of the participants do not know what SD is and what its principles are about, although they follow some of its principles in their domestic activities. This suggests that SD and its principles are poorly introduced and explained in the curricula, while students are not involved in activities which may encourage them to employ these principles in their professional and personal life. Changes should be made at all levels of education, and lifelong learning should be acknowledged as an essential tool in professional and personal development.

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SECONDARY SCHOOL TEACHERS' AND STUDENTS' APPROACHES TO POSSIBLE SOLUTIONS OF ENVIRONMENTAL PROBLEMS IN ANKARA, TURKEY

Tahir ATICI

Gazi University, Gazi Faculty of Education, Biology Department

tahir@gazi.edu.tr

Elçin EDİS

Gazi University, Institute of Educational Sciences, Biology Department

ecoland@hotmail.com

Melike ÖZER KESKİN

Gazi University, Gazi Faculty of Education, Biology Department

mozerkeskin@gmail.com

ABSTRACT

Several institutions, the municipality being at the forefront, conduct studies and offer suggestions concerning the environment conditions in Ankara. "Planting on Martyrs' Lands" and "Tree Surgery and Landscaping the Capital" were conducted and then "Integrated Biological Control" program was developed. Results of this study indicate that students and teachers have general information about the environment however, they are not aware of their living environmental problems and ongoing studies. Environmental works, which Ankara Metropolitan Municipality pursues, are tried to publicize by media but those announcements either do not reach the education sector or are not enough taken into account.

Key words: *Environmental awareness, Environmental problems, Environment-related projects, secondary school.*

INTRODUCTION

Environmental problems faced in Ankara have been increasing with its growing population. Ankara is faced with some environmental problems such as energy efficiency, waste destruction, waste treatment and recycling, drinking water purification, preventing the spread of contagious and infectious diseases preserve natural habitat in Ankara, air pollution, noise pollution, unplanned urbanization.

Environmental education is very important to monitor environmental problems closely, to create a healthy environment, to have people who are aware of individual rights and responsibilities and ensure the consciousness of environmental problems and contribute in solving them. In other words, the purpose of education for environment is to have a sustainable development and to show people ways to living in peace with nature (İleri, 1998).

The individuals who are responsible for the occurrence of environmental problems should be conscious of eliminating these problems. This will be possible only with an active environmental education. In the environmental education, the target population is all individuals and the goal is to develop their sensitiveness, positive attitudes and behaviors towards environment (Özmen, Çetinkaya and Nehir, 2005). Therefore, in this study, answers were sought to the following questions:

1- How informed are the secondary level teachers and students living in Ankara about the environmental problems in Ankara?

2- How informed are the secondary level teachers and students living in Ankara about the solutions recommended for the environmental problems in Ankara?
3- Do the secondary level teachers living in Ankara give importance to environmental education?
4- How far might the solutions recommended for the environmental problems in Ankara be applied to the field of education?

The awareness of teachers being the intellectual part of the society and students who will be intellectual people of the future about environmental problems of the city they lived are curious. The impotency of environmental education can be revealed by determining the level of knowledge and the applicability of this knowledge of secondary education teachers and students lived in Ankara.

As mentioned earlier, the environmental education of future generations will increase their environmental awareness. This research is important to understand how far they are ready for the potential future environmental problems and to know their environmental conscious level as a future parents and teachers.

METHODS

In this study the general screening model was used. Data were obtained through the questionnaire, which was developed by the researchers, to determine how the secondary level teachers and students in Ankara are informed about the environmental problems and their solutions, and their relevant actions.

In the process of creating a survey, Ankara's environmental problems and the latest information about the Municipality’s solutions for these problems were gathered by following an official web site of Ankara Metropolitan Municipality and its published periodicals. At the same time at Ankara's natural riches were investigated (Ankara Metropolitan Municipality, 2008; Atatürk Forest Farm, 2009; The Ministry of Environment & Forest, 2009). To create a survey the statements related to some topics were prepared. After the preparation of the survey, its reliability and validity studies were conducted. The survey was conducted on The Gazi University, Gazi Faculty of Education, Science Department the 3rd grade students in order to determine the reliability of the survey. The reliability of the test was found as $\mu = 0.76$. Then the survey was conducted among 9^{th}, 10^{th}, 11^{th} and 12^{th} class students and the teachers in 4 different high schools in Yenimahalle, the district of Ankara. 118 high school students and 30 teachers participated in this study.

RESULTS

1. Environmental Awareness

Survey results were revealed that students are worry about the environment and its future. The rate of warning people who pollute the environment was 61%, which is pleasing. This indicates that the environmental awareness of students has already developed. 75.4 percent of students are worrying about whether their children will live in a clean environment in the future. The rate of students’ awareness about environmental studies was low. This indicates that environmental studies cannot be presented enough or they are not introduced sufficiently at media and technology tools which students use frequently.
43 percent of teachers think that environmental studies are sufficiently presented by media but 33 percent of them do not so. This shows that ongoing environmental studies are not sufficiently announced. Also, the teachers are not aware of environment-related works.

2. Ankara's Environmental Problems and Solutions

Survey results showed that teachers and students did not have enough information of Ankara's environmental problems and ongoing studies to resolve those issues. Teachers and students were not aware of the fights against houseflies, mosquitoes and head louse. In addition, they had information about plant cultivation to increase green areas, but they did not know that whether or not properly done.

3. Ankara Metropolitan Municipality's Studies Related to the Environment

73 percent of the students found that the efforts of Ankara Metropolitan Municipality on environmental works were sufficient. 53.3 percent of teachers found the same works as sufficient. The study results showed that teachers know much more than the students considering environmental works of Municipality.

4. Ankara's Natural Richness

The results of study showed that teachers and students participating to the study did not have enough information on Ankara's natural richness. Only 36.4% of the students and only 33% of teachers know that rabbits, foxes and hawks live their natural life in an area of 7600 decars belonging to the Atatürk Forest Farm in Ankara. Student responses to the statement "I know that organic products will be sold and villagers will have the natural village (rural) life in Muratlı, an ecologic village located at a distance of 58 km to Ankara" are following. 43.2 percent of them chosed "do not agree" and 51 percent said "undecided". Teacher responses to the same statement are that 38 percent said "do not agree" and 38 percent said "undecided". Results show that students and teachers are not aware of conducted organic life in the village of Muratlı.

CONCLUSIONS

Today, the rapidly increasing world population, rapid industrialization and unhealthy urbanization, nuclear experiments, pesticides, artificial fertilizers, chemicals have started increasingly polluting the environment, thus; the contaminated air, water and land have become harmful to all living creatures and finally each has turned out to be an environmental problem with which we face now. These problems might be overcome radically by educating students from primary schools to all level schools. Survey results indicate that students and teachers have common information about the environment, however they do not know enough their living environmental issues and ongoing works for the relief of environmental problems. The environmental works conducting by Ankara Metropolitan Municipality are tried to publicize by using the media, but those announcements do not reach the education sector, or are not enough taken into account.

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THE ELEMENTARY SCIENCE TEACHERS' USE OF MEASUREMENT AND EVALUATION TECHNIQUES

Ela Ayşe Köksal
Niğde University
eakoksal@nigde.edu.tr

Hülya Yıldırım Ekinci
Niğde University
hulyaekinci@nigde.edu.tr

ABSTRACT

With the recent reform in Turkey, science curriculum has accepted more constructivist approach to measurement and evaluation and given importance to alternative evaluation techniques.

This study aims to explore the degree to which elementary science teachers use these techniques. A survey with 58 teachers in Nigde city, town and village showed that the teachers' use of the techniques formed seven dimensions: (1) Traditional and Close-Ended, (2) Conceptual, (3) Student-Centred, (4) Traditional and Open-ended, (5) Long-Termed and Authentic, (6) Dialogic and (7) New and Alternative. This study also aims to explore the usage level of these measurement and evaluation techniques and see if any or some of the dimensions are used more (or less) than the other techniques forming a specific dimension.

Keywords: *elementary science teachers, measurement and evaluation, curriculum.*

INTRODUCTION

Measurement and evaluation has an important place in education and teaching because it aims to assess the quality of education and make it more successful by eliminating the shortcomings. Additionally it is used to determine the degree to which the course objectives are met, what subjects are taught, and which student characteristics are affected by teaching.

In constructivist approach, assessment should not be done apart from the teaching/learning process. Rather it should be done continuously.

With the recent curriculum reform In Turkey, science curriculum has accepted more constructivist approach to measurement and evaluation. The new program has given importance to alternative techniques, such as performance evaluation, portfolio, concept map, structural communication, diagnostic tree, word association, project, drama, interview, written report, demonstration, poster and group-, peer- and self-evaluation.

It is reported that due to time limitations, material shortage, class population excessiveness, and teachers' unsuitability, the program has potential drawbacks.

This study aims to explore the degree to which elementary science teachers use these techniques. This study also aims to explore the usage level of these measurement and evaluation techniques and see if any or some of the dimensions are used more (or less) than the other techniques forming a specific dimension.

METHODOLOGY

The population of this study was all elementary science teachers attending village, town, and city elementary schools in Nigde. The sample on the other hand was 58 teachers who completed a questionnaire during the seminar activities in their schools on June 2009. The questionnaire was intended to evaluate the elementary teachers' degree to use measurement and evaluation techniques in their science lessons. The science and technology curricula for elementary 4-5 and 6-8 grades were used by the researchers to construct the item statements. The questionnaire had 22 items and five-point-Likert scale.

The data from the teachers were analyzed for validity (KMO and Bartlett's Test, and factor analysis), and reliability (in terms of internal consistency) issues and factor analysis was done. The conclusions were drawn by considering the mean scores of the teachers' responses to the each item.

RESULTS

The Cronbach Alpha value of the questionnaire data was found to be .82, which states that the instrument is reliable enough to use in determining teachers' in-class assessment applications. Moreover corrected item-total correlation values were above .20, which states that all items are contributing to the whole measure as well.

The investigation of the data with the KMO Test gave enough result (.63) and Bartlett's Test was significant to conclude that the data were ready for factor analysis. The factor analysis was conducted with principal component analysis with varimax rotation. The result of the factor analysis showed that the teachers' use of the techniques formed seven dimensions, which contributed to the 75% of the variance on the scale scores: (1) Traditional and Close-Ended, (2) Conceptual, (3) Student-Centred, (4) Traditional and Open-ended, (5) Long-Termed and Authentic, (6) Dialogic and (7) New and Alternative.

When the mean scores representing the teachers' usage level of measurement and evaluation techniques were considered, it was found that the teachers use long termed and authentic ones nearly always (the means are 4.44 for performance evaluation and 4.08 for project).

The teachers use dialogic techniques usually in their science classes (the means are 3.81 for concept map and 4.06 for question-answer test),

The teachers use traditional close-ended techniques usually in their science classes (the means are 4.13 for multiple-choice test, 3.96 for fill in the blank test, 3.92 for matching test and 3.79 for true-false test).

Though the mean score is little bit high for short essay test, the teachers are likely to use traditional open-ended techniques sometimes in the science and technology lesson (the means are 3.42 for short essay, 2.98 for long essay and 2.90 for interview types).

The teachers use conceptual techniques sometimes at the class (the means are 3.19 for demonstration, 3.13 for word association, 2.98 for diagnostic tree, 2.88 for drama and 2.81 for structural communication).

Among the new and alternative techniques, the teachers are likely to use poster (3.83) and portfolio (3.56) usually, but use written report (2.81) sometimes.

Lastly, the teachers seem to use student-centred techniques sometimes (from 2.75 to 2.81).

CONCLUSION

This study revealed that the teachers though in some of the dimensions might use alternative techniques less; they could implement the techniques at class. Alternative techniques as the curriculum suggests are reliable, performance based, valid, constructivist and applicable. And they can help teachers to understand what, why and how to teach as well as to measure meaningful learning and deal with students' misconceptions and learning difficulties.

The teachers' responses to the questionnaire were indicated a clear difference between traditional and alternative techniques stated by the curriculum. For example multiple choice, fill in the blank, matching and true-false tests constructed a separate dimension. On the other hand, question-answer technique was loaded in the factor with concept map that is though to be alternative. From the dialogic teaching, teacher-student talk and feedback point of view and the personal experience (of the first author) it can be said that the aim of classroom assessment should be to guide students on their school learning.

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IS TECHNOLOGY AN ATTRACTIVE SCHOOL SUBJECT? A PILOT STUDY OF THE SUBJECT IN THEORY AND PRACTICE.

Ylva Bjelksäter
University of Gävle
ylabjr@hig.se

Edvard Nordlander
University of Gävle
enr@hig.se

ABSTRACT

How does a teacher convey technological understanding through interactions with learners?

A case study is performed using a stimulated-recall methodology with one teacher in a limited Technology learning module in grade 8. Based on the official syllabus and local interpretations, what in fact occurs in the meeting with pupils is discussed regarding how technology is portrayed by the teacher.

An important result is what messages about technology the teacher is expecting the pupils to understand from each lesson. In order to get appropriate feedback, selected pupils are interviewed about their impressions of the lesson.

Keywords: *stimulated recall, Swedish compulsory school, technology subject, syllabus fulfillment, effect.*

INTRODUCTION

Technology was introduced as a mandatory subject in Swedish compulsory school in 1980 and got its own syllabus when the current national curriculum was introduced in 1994. Each school can decide when and how the pupils get technology education, but every pupil is expected and entitled to reach the national goals (SFS No: 1985:1100), *i.e.*, learning outcomes set by the government.

In order to find out if and how pupils reach the national goals in Technology an investigation is performed about how the specific Technology syllabus is interpreted, in theory and practice. The findings of the project will contribute with answers about the state of the Technology education in the Swedish compulsory school system, and how the subject could be developed in the future. In this paper the first results are presented.

According to Alexandersson (1996), a teacher is continuously performing spontaneous acts without much of reflection, commonly referring to habits "we usually do it like this" or a feeling of justification "it feels right to do it this way". Many of our actions are guided by habits and/or emotions, and the teaching situation is seldom an exception.

METHOD

Research question: How does the teacher convey/develop technological understanding through their interactions with learners?

The interpretation of the syllabus is studied through observations. This pilot study is performed as a case study with a teacher in a limited module of the Technology subject in grade 8 (14-15 year old pupils). The teacher is chosen by the school management as favorable example of good practice. The method is based on a stimulated-recall interview methodology (Walmsley 2008, Alexandersson 1994, Calderhead 1981). In the stimulated-recall interviews, video filming is a substantial part of the method. Thus, a miniaturized video camera is hooked on the teacher recording the actions in class of the pupils along with the dialogue between teacher and pupil. In the interview part, the video clips are used to help the teacher to recall the interaction at various moments and explicate his interactive thinking.as regards situation, strategy, thinking, reactions, learning impact, etc.

The results of the stimulated-recall interviews will be put upfront to the syllabus and other guiding official or semi-official documents. Interviews are conducted with the pupils about how they perceive the technology education in order to get some receiver feed-back of the education

The case study

The assignment is to construct a model of a house, either from a template of a log cabin, or an existing house in their neighborhood. Available for the construction are popsicle sticks and flower pegs, hinges, glue, and various tools. There is no specific laboratory for the technology education, so a regular classroom is used where the material and tools are presented on a trolley, and the pupil-made models are stored on shelves in the classroom between lessons.

The groups are composed by the pupils themselves, and there are 6 groups with 2-5 pupils in each: The learning module is arranged with only one 45-minute lesson per week for almost a full semester.

The teacher (male, 50 years old) has been teaching for 20 years and is considered quite experienced. His teaching subjects are Mathematics and Science (where Technology normally is included). He has taken in-service training courses in Technology. He is has a calm personality and rarely gets annoyed. He is appreciated both by pupils and colleagues.

The assessment of this teaching module is done by the teacher based on four criteria: quality, details, aesthetics, and cooperation. The governmentally set learning outcome by the end of the 9th year for this module of Technology education is: To be able to build a technical construction using own sketches, drawings or similar support, and to describe how the construction is built up and operates.

RESULTS

When the pilot study started the pupils had already begun with the constructions. At the first visit they were sawing, rasping, and putting the flower pegs together with clue. At the second and third visit they were still occupied with this.

The pupils thought it was boring because it took so long time to saw and rasp all the popsicle sticks and flower pegs. They made little progress, and some of them did not believe that they would be ready on time. The teacher had not yet decided when the project should be finished. However, at the fourth visit one group had started with the roofing.

Not all pupils were taking responsibility for the work. A couple of boys did not seem to be doing much, and most of the time they just sat and watched the others working.

When asked, the pupils said they enjoyed Technology although it was sometimes boring. The reason for this opinion was the practical character of the subject and the lack of formal tests. However, they did not have the feeling of learning anything new. Furthermore, they were not sure what would be assessed by the teacher when grading the pupils' achievements in the Technology subject. Some of them, however, remembered something about cooperation as an important criterion.

CONCLUSIONS

The results give an impression of what in fact occurs in the meeting with the pupils, and how the meaning of Technology is portrayed and conveyed by the teacher to the pupils. For the specific module of learning typical knowledge and skills are involved.

In the interactions between teacher and pupils, the language used for communicating the learning issues is of major importance. So, an important result is to find out what messages about technology the teacher is expecting the pupils to understand from each lesson. The results show that assessment criteria are not clear to the pupils. Only the cooperation criterion was given by some pupils, but *e.g.* the aesthetics criterion was not understood.

An impression of boredom compensated by the lack of formal tests is giving the Technology subject a character different from other school subjects. This is most certainly neither the intention of the authorities nor the teacher.

A major intention of the teacher with the assignment is to evaluate how the pupils cooperate and which different solutions they use to solve the task. Due to the divergence in interest emerging through the low pace during lessons, this assessment will be very difficult. It is not the subject *per se* which is diverging the pupils' interests. It is the circumstances around it, *e.g.*, the non-technical environment, lack of material, the formation of groups as regards size and membership, low speed of progress, organization of lessons.

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EVALUATING THE IMPACT OF ENVIRONMENTAL EDUCATION: COMPARING THE NEP AND THE 2-MEV AS OUTCOME MEASURES

Jelle Boeve-de Pauw
University of Antwerp
jelle.boevedepauw@ua.ac.be

Peter Van Petegem
University of Antwerp
peter.vanpetegem@ua.ac.be

ABSTRACT

The environmental worldview came to researchers' attention in the mid-seventies and is now making its way into the evaluation of EE. The use of this non-cognitive, yet quantitative evaluation method is promising in the current era of accountability. In this paper, we compare the theoretical foundations of two contemporary measures for children's environmental worldview: the NEP and the 2-MEV. Both scales are used to tap children's environmental worldview (n=1287), and to assess the impact of a popular environmental education school (n=60) programme using multilevel analysis.

Keywords: *2-MEV, Children's NEP, Educational Evaluation, Environmental Worldview, Multilevel Analysis*

INTRODUCTION

Evaluation of environmental education initiatives is a very difficult and complex task, but one that is of outmost importance. The degradation of the natural environment is increasing exponentially. The way humanity is mistreating the earth and its natural riches in a single lifetime will impoverish our descendants for all time to come. Knowing this, it is clear that environmental education has to be effective. A concept that is making its way into the evaluation of environmental education is that of the environmental worldview, first described by Dunlap and Van Liere (1978). It consists of what social psychologists call a set of *primitive beliefs* that constitute the inner centre of a person's belief system on the truth about the physical and social reality. Instruments that try to capture this concept are abundant since numerous authors have developed their own instruments for their specific studies. As Leeming, Dwyer & Bracken (1995) point out, the availability of a carefully developed and psychometrically sound scale to measure children's global environmental attitudes (or environmental worldview) would be a valuable teaching and research tool. Such a scale would provide one common standard against which the effectiveness of various interventions could be judged and compared. These comparisons would greatly facilitate the systematic development of more effective interventions to promote pro-environmental attitudes (and behaviours). Recently two scales are receiving increased attention in this area of EE research: Manoli, Johnson & Dunlap's (2007) Children's New Ecological Paradigm (NEP) scale, and Bogner and Wiseman's (2006), Model of ecological Values (or 2-MEV). The children's NEP sees the environmental worldview of children as a one-dimensional trait with Ecocentrism and Anthropocentrism as extremes, whereas the 2-MEV is two-dimensional by design and structurises youth environmental values on the orthogonal factors Preservation and Utilisation. Furthermore, Johnson & Manoli (2008) show that the environmental worldview of children can be considered both as stable when students are not exposed to EE and as changeable when students are exposed to EE. Both the children's NEP and the 2-MEV have been used to illustrate difference between groups of students and the impact of EE. The current paper compares the theoretical foundations of both scales, and goes deeper on the assumptions of using worldview based scales for EE evaluation.

AIM AND METHODS OF THE STUDY

Both instruments (NEP, α=.70; 2-MEV: α(P)=.81, α(U)=.86) were used to measure the environmental worldview of Flemish children (n=1287, ages 11-13), and to assess the impact of a popular Flemish EE school programme. In total 60 school participated in the study, 30 of which were enrolled in the EE programme; the other paid no specific attention to EE. We furthermore collected data on the children's gender, socio-economic background (α=.68), environmental knowledge (α=.87), affections toward the environment (α=.95), environmental behaviour (α=.75) and behavioural intentions (α=.79). The data were analysed using a multilevel regression approach, allowing for differentiation between individual and school level effects. We furthermore built a structural equation model to test for both environmental worldview scales the theoretically assumed link to behaviour and the potentially mediating functions of environmental affection and knowledge.

RESULTS AND DISCUSSION

The multilevel analyses reveal that the EE programme has an effect on the students' environmental worldview (as measured by both scales). At the school level, students from schools that participate in the EE programme score .320 standard deviation higher on the NEP scale than non-EE schools, indicating that they have a more ecocentric way of looking at the world. If we look at the 2-MEV, we see a school effect of -.320 for the Utilisation factor (U) and no school effect for the Preservation factor (P). These results nuance the NEP effect in that they reveal the EE schools to temper their students' utilitarian views of the natural world but that they do not stimulate their preservative values. The next step in our analyses was to build a path model to test if behaviour change (the ultimate goal of EE) can be reached through schools affecting only the U factor. This model shows that, through the mediating effect of behavioural intentions, it are preservative values that affect behaviour (β=.52), whereas utilitarian values have no effect. Furthermore we integrated environmental affection and knowledge into the path model, the results of which show that students P views (and thus ultimately behaviour) can be reached through affection (β=.55), and their U views through knowledge (β=-.41). We then also compared affection and knowledge scores between the schools that do and do not take part in the EE programme, and showed that EE schools are mainly increasing their students' knowledge about the environment, without connecting that increase to a augmented affection for the natural world. Though the EE schools' self-declared primary EE aim is to work on the affective side, they seem to – unwillingly and unknowingly – have a cognitive focus.

CONCLUSIONS

Both instruments showed to be valuable in the context of evaluating EE in school. Based on the NEP results, the EE schools seem to be doing great work, if we look at the image the 2-MEV results show, than the picture becomes more nuanced. The NEP's one-dimensional approach to measuring the environmental worldview of children might be too straightforward and when used to evaluate EE programmes and lead to inflated conclusions. The 2-MEV on the other hand showed the link to the affective/cognitive divide and proved, for the EE schools, to be the more informative instrument.

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CHANGING LONG-TERM ADOLESCENTS' ENVIRONMENTAL PERCEPTION THROUGH SHORT-TERM EDUCATIONAL PROGRAMS?

Franz X. Bogner

University of Bayreuth
Centre of Math & Science Education (Z-MNU)
franz.bogner@uni-bayreuth.de

Michael Wiseman

University of Bayreuth
Centre of Math & Science Education (Z-MNU)
franz.bogner@uni-bayreuth.de

ABSTRACT
We used the 2-MEV model of Bogner and Wiseman (1999, 2002, 2006) which is covering the two independent ecological values, Preservation and Utilization, in order to evaluate educational programs within a National Park by applying pre- and post-testing procedures. The model was developed in a series of studies, nationally and internationally, by proofing its validity for measuring adolescent environmental perception within a European context (Bogner 1998, 2000; Bogner & Wiseman 1997, 1998, 1999, 2002, 2004, 2006). Later on, the empirical model was independently confirmed by Milfont & Dukitt (2004, 2006) for an Australian population and by Johnson & Manoli (2009) for an American one. Thus, the model provides a valid empirical basis to evaluate educational programs within a National Park by applying a pre- and post-testing frame.

Keywords: *environmental perception, attitudes, values, 2-MEV model, European study*

INTRODUCTION

Environmental problems nowadays are worldwide problems also requiring solutions at a global level. As a main cause of environmental degradation numerous authors identified the Dominant Western (Social) Paradigm (Dunlap & Van Liere, 1978, Disch, 1970, Milbrath 1984) which considers human-beings as separate and superior to nature as well as non-human creatures as important just proportionally to their usefulness (Gardner & Stern, 1996). This anthropocentric and materialistic world view includes the belief in economic growth building upon exploiting the seemingly ample resources and naively believing in technological progress that will solve any potential problems. This extreme paradigm is thought to be contrasted by an eco-centric worldview that gives nature an intrinsic worth and considers humans as part of nature. This so-called New Environmental Paradigm (Dunlap & Van Liere, 1978) or Deep Ecology Paradigm (e.g. Devall & Sessions, 1985) rejects environmentally destructive lifestyles and advocates a decrease in human population.

A general frame of values in the sense of important life goals as potential basis for anthropocentric or eco-centric attitudes and worldviews is a frequent study issue. According to Barnouw (1985), values (and attitudes, beliefs and behaviours), shared by a group of people and communicated from one generation to the next, correspond to the definition of culture. A good example within the context of environmentalism is the difference between Latin-American and Anglo-American worldviews as described by Deutsch Lynch (1993). Whereas the more anthropocentric and dichotomized Anglo environmentalism considers wilderness as "not been touched by the hand of man", sees the Latin environmentalism human-beings as integral part of nature rather than as its protectors and consumers. Studies comparing non-Hispanic with Hispanic respondents consistently described the latter as more concerned about the environment and more eco-centric represented by higher scores on the NEP scale (e.g., Noe & Snow, 1990).

The specific objective of this present study was to complement the “very little multinational environmental research” (Schultz & Zelezny, 1999). First, we extend the previous research with regard to the differentiation of environmental values by applying the Preservation and Utilization scales of Bogner and Wiseman (2002, 2006) and repeating the two-factor structure by explorative factor analysis.

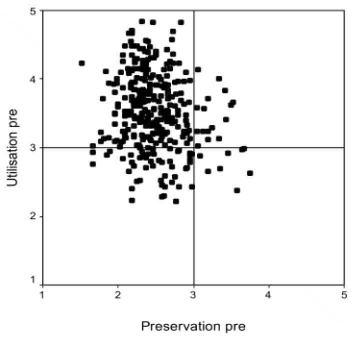
DESIGN AND METHODOLOGY

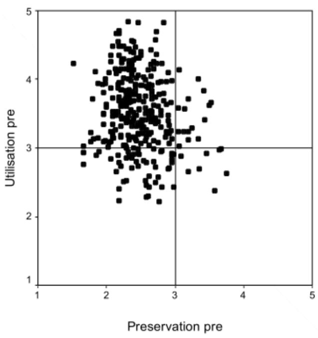
Maximum likelihood factor analysis confirmed the two hypothesized orthogonal factors U and P of the 2-MEV model (Two Major Environmental Values) as sets of related attitudes. Thus, all participants could be allocated with regard to their scores in U and P by assigning them to quadrants including P+ and P-, U+ and U-. Consequently, due to the two test cycles changes within this allocation were monitored. The weeklong education program consisted of an extra-curricular unit in a field centre within a National Park.

RESULTS AND PROSPECT

The program caused a shift within the scale of environmental perception, preferable occurring in the consistent direction of favoring nature and the environment. Scores on the higher-order factor of Preservation (P) increased, those on Utilization (U) decreased (see figure below). Comparisons with the control group confirm the impact of the program. Differences between the pre-test scores of the control group and those of the treatment group were not significant; differences between the post-test scores were highly so. For both, the degree of change for the Preservation and Utilization scores to the pre-intervention scores, summarized as the regression line running through the cluster of points marking the position of each individual. In both cases, a clear regression downwards from left to right appears – the lower the pre-intervention score, the greater the degree of change. Furthermore, individual points cluster very closely about the regression lines, demonstrating a high degree of consistency in the positive effect produced by the intervention. Both shifts within our pre- and post-tested variables are discussed in the context of related studies using the same empirical survey instrument (Bogner, 1998, 1999, 2002; Bogner & Wiseman, 2004, 2006).

Particularly in the area of environmental education concern has always proceeded beyond the imparting of knowledge to changing adolescent attitudes, and even modifying their long term environmental behavior. The 2-MEV model yielded the further advantage that intervention studies throughout the series are comparable, since the core of the instrument has remained constant over decades.





Literature upon request from the authors.

TEACHING RADIOACTIVITY WITH THE AID OF THE MOVIE *MADAME CURIE*

Daniel Marcos Bonotto

Instituto de Geociências e Ciências Exatas / IGCE / UNESP / Rio Claro / Brazil

E-mail: dbonotto@rc.unesp.br

ABSTRACT

This paper evaluates some aspects that should be considered when using the movie *Madame Curie* movie as a didactic support for teaching radioactivity. Despite the cinema has been recognized since its earlier days as an important tool in people education due to its ability of telling histories by images, the teachers should promote opportunities for discussion in their classes of the views concerning to the scientist task and of some scientific aspects focused in the film.

Keywords: *Cinema, Education, Radioactivity teaching, Movie Madame Curie.*

INTRODUCTION

The cinema is a typical product of the occidental modernity and an amalgam of Art and Science, expressing a historical moment that forms a new aesthetical experience (Loureiro, 2008). Beyond the initial entertainment purposes, it was also started several relationships between education and cinema, as discussed by many investigators who recognized several films in formal and no-formal educative projects (Loureiro, 2008; etc.). Under this perspective, two different forms of cinematographic expressions (scientific and pedagogic nature) had occurred together and were frequently mixed in the beginning of the 20th century, despite, in the present days, there is a distinction between scientific cinematography (linked to the cinematography use for scientific investigations, their documentation and diffusion) and educational cinematography (associated to the cinematography use for general education and public instruction, where the cinema is utilized in the school environment) (Duarte & Alegria, 2008). There is an intense debate concerning to the fact that the role of reality is in no way the one of being copied, reproduced, or represented in the most truthful way, however, the “pedagogic vocation” of the cinema has been recognized since its earlier days as it allowed the use of news parameters to the art of telling histories by images, contributing to the people education, inclusive outside the schools (Duarte & Alegria, 2008). The purpose of this paper is to present the use of the movie *Madame Curie* (Flanklin & LeRoy,1943) for teaching radioactivity, pointing out some aspects related to science and scientific activity in a more appropriate view that the film show us.

METHODS

The radioactivity is a subject focused in many disciplines and a brief history of the film production is presented to the students before its exhibition. It is told to the students that following her mother's death, Eve Curie wrote a biography about her mother, after collecting and sorting various documents and letters left by Marie Curie, who discovered the radioactivity together with Henri Becquerel and Pierre Curie. The information, letters, and photographs she obtained were used in the writing of Marie Curie's biography, *Madame Curie,* published simultaneously around the world in 1937. Then, some information is provided about the 1930s decade (and most of the 1940s as well) for the cinema, as it has been labeled *The Golden Age of Hollywood*, although most of the cinema output of the decade was black-and-white. Afterwards, the steps of the film production are described, considering that in March 1938, Aldous Huxley was contacted by MGM for a writing contract in order to make a movie based on the book *Madame Curie* by the scientists' daughter Eve. The film *Madame Curie* was originally to star Greta Garbo and be directed by George Cukor, however, MGM ultimately rejected Huxley's script for it as "too literary". In 1943, the biography was finally adapted by MGM and released as a film having the performance of Greer Garson as Marie Curie, direction of Mervyn LeRoy and screenplay by Paul Osborn and Paul H. Rameau. After this initial historical information, some parts of the film concerning to the radioactivity and radium discoveries are exhibited to the students. Then, they are requested to express their opinions about them and many situations offer rich opportunities to discuss the conceptions of science and scientific activity showed by the film that are compared with those of the science educators nowadays consider as more appropriate (Sjøberg, 2004).

RESULTS

When the students are induced not to be mere film viewers but active thinkers on the messages veiculated in the parts of the film exhibited, a lot of questions arise. For instance, the film *Madame Curie* was heavily fictionalized for dramatic purposes and the discovery of radium appeared glamorous, following the typical formula of the Hollywood's films in that period, which was inspired on the big industries for producing automobiles, electro-domestics, canned food, etc. Such industrial organization was also applied to the production of films and involved (Loureiro, 2008): a big mode of production for realizing the films from the existing studium models, mitification of actors and actresses (star system), and adoption of the ruler code for the messages veiculated in the films in order to sustain the harmony between Hollywood and the institutions responsible by the moral maintenance in the USA society. The movie *Madame Curie* combined romance with edification, a sure-fire recipe for success in that era, so that the formula allowed it to receive seven Oscar nominations, including Best Picture, Best Actor, and Best Actress. Despite to be more historically accurate than most biographical films of its time, it omits any mention of Marie's family in Paris, including her sister Bronislawa, with whom she was very close, as well there is also virtually no mention of Marie's intense devotion to politics and the liberation/independence of her native Poland. This, obviously, would permit to recognize the strong links between the scientific activities and the social, political and cultural contexts that influence them. Additionally, the movie promotes opportunities for discussion with the students of the views involving the scientist task and of some scientific aspects focused in it, in order to clarify the actual achievements in the laboratory experiments held during the initial and following years of the radioactivity discovery. For example, Henri Becquerel himself reported the first observation of an effect of gamma rays on human tissue when, 10 days after he had carried a small amount of radium in his shirt pocket for 6 h, he got a kind of burn, which healed spontaneously in a few weeks, leaving a depigmented scar (Mazeron & Gerbaulet, 1998). Pierre Curie confirmed Becquerel's finding by deliberately applying radium powder on his forearm for 10 h and both published a paper in 1901 describing the physiological action of the radiation associated to radium (Mazeron & Gerbaulet, 1998). But the film makes no mention of these findings, as it contains scenes describing the burning effects only in Marie Curie's hand, according to the approach of the "star system" of the Hollywood's formula. It is also pointed out that even the Eve's book *Madame Curie* makes no mention to this aspect, as other health diseases with Marie Curie were described when experiments were realized in a "miserable old shed" from 1898 to 1902. Therefore, the film reinforces the view of the science constructed by solitary and missionary individuals situated above the society standards rather than the collective knowledge production subjected to right answers and mistakes. The movie is ended with a discourse attributed to Marie Curie, where the science is glamorously claimed as a big humanity benefactress, which is an ingenuous perspective that must be emphasized in the educational process related to Science Education.

CONCLUSIONS

The film *Madame Curie* has cultural and artistic values because it was well-filmed. It can be usefully utilized as a didactic support for teaching not only radioactivity but the science activity itself. However, situations like presented here must be critically analyzed in order to attend the Science Education purposes. The teachers must promote opportunities for discussion in their classes of the views involving the scientist task and of some scientific aspects focused in the film.

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PHYSICS AND ART: AN INTERDISCIPLINARY APPROACH IN ELEMENTARY SCHOOL

Marco Braga
CEFET-RJ/Teknê Group
braga@tekne.pro.br

Andreia Guerra
CEFET-RJ/Teknê Group
aguerra@tekne.pro.br

José Claudio Reis
UERJ/Teknê Group
guerrareis@tekne.pro.br

ABSTRACT

This paper is a description of an experience aimed at introducing an interdisciplinary approach in final grade of Brazilian elementary school. The aim is to show the transformation of the conception of space and time from the Aristotelian physics to the Einstein conception. These changes were accompanied by new visions of space and time both in Physics and Arts. The comparison between two expressions of human culture is used to introduce points of third culture (Snow, 1993).

Keywords: *science education, science and art, space and time.*

INTRODUCTION

The study of Physics in Brazil, in both elementary and high schools does not contemplate the developments of Aristotelian Physics and the Modern Physics. Aristotelian Physics is considered dead and Modern Physics presents many difficulties in using mathematical language. The purpose of this work is to understand the transformation of beliefs of the students about the nature of science from a course with a historical and philosophical approach, where science is seen as part of culture. In this approach, the new notion of space-time in Physics is compared with other contemporary cultural representations dealing with the same subject.

THE COURSE

A one-year Physics course was developed specially to deal with the study of space and time. The course introduced the latest three significant worldviews originated in Western civilizations and discussed the basics of the two transitional periods in between (Reis et al. 2001). These are extremely rich periods for the argumentation that arose, and also because they normally go beyond the scientific field (Fleck,1986).

During the first period, the transformation of the Aristotelian to the modern world view was discussed, and the shift from a closed to an infinite universe. This view was studied, as well as the planetary models of Ptolemy, Copernicus, Brahe, and Kepler. Within this stage, the basic classical mechanics notions were introduced: Kepler's Laws, Newton's Laws, including the universal law of gravitation.

As artists and scientists shared the same cultural environment, it was discussed what was happening concerning art back then. So aggregate space in medieval paintings was compared to the new idea brought by the discovery of perspective, whereby it was possible to go from a closed to an open space where infinity could be conceived (Edgerton Jr, 1993). This was done by projecting medieval frescoes and Renaissance paintings.

During the second period, when this activity was carried out, we introduced Einstein's new concept of space-time. Here, the students noticed the change in the world view and the new construction of gravitation based on space-time curvature.

In this transition period, new scientific ideas were introduced as part of a deeper transformation *(Galison, 2003)*. At this point, art came into play. Paintings by Claude Monet where the same scenerey was painted several times at different times were presented to students (Shlain, 1991). The new conception of space from Picasso illustrated the transformation in the art. In literature, at the end of Eighteenth century, H G Wells (1992) wrote the "Time Machine", where a scientist presents a new space-time conception.
During all course basic mathematical tools were used.

THE METHODOLOGY OF RESEARCH

The course was applied at a school in Rio de Janeiro during 36 weeks to 14-15 year-old students. The teacher had 50 minutes a week to work with them. The teacher occupied the time presenting the subject, correcting the exercises and applying the evaluations. There were 180 students divided into 5 classes.

The research was qualitative methodology. All data were collected by the teacher with a ethnographic view. The teacher wrote his observations after classes in a diary where he added his comments too. In this diary, statements of several students and their dialogues with the teacher were recorded. Each week, all observations recorded in the diary were discussed by a group of academic researchers and teachers. The group evaluated the process during it application.

RESULTS

After applying this course during two consecutive years, it was possible to reach the conclusion that this approach shows a new way to learn Physics. Some students feel uncomfortable with the fact that theories change over time. This situation showed that it is very important to focus the courses in the specific transition moments, or, as Kuhn's (1963) put it, in the revolutionary moments. For instance, when the teacher started presenting Einstein's model of spacetime to explain the new vision about gravitation, a student asked him:

> "You are going to explain another model? Why did you start the explanation with this model, since it is the right one?" (student)

The belief about absolute and immutable truth has been broken. They were starting to understand the nature of science. The students understood science as a process. This can be clearly seen with another question brought by them:

> "How to know that this model is the last model? The truthful model!" (student)

On the other hand, the relationship between science and art has also brought a new vision about the construction of scientific knowledge. Scientific models were perceived as creations of men and women by means of their relationship with nature. But this approach led students to know that scientists don't work out of the world. Their creations dialogue with others areas of knowledge and values. Metaphysics is part of the construction of knowledge. Scientific construction dialogues with religions, philosophy, and arts.

CONCLUSION

This research has been intended to know the student's conceptions about nature of science through relationships between science and art. In the coming years we intend to construct a picture more detailed from these conceptions and their transformations. It was clear that there is a need for deeper understanding through a survey on a larger scale. The relationship between science and art is a good way to know how can be transformed the student's belief about the construction of scientific knowledge.

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A PRE-SERVICE CURRICULUM IN LEARNING TO TEACH ARGUMENTATION IN SCHOOL SCIENCE AND TECHNOLOGY: A REFLECTIVE ANALYSIS

Martin Braund

Cape Peninsula University of Technology, Cape Town, South Africa

mb40@york,.ac.uk

Peter Hewson

University of Wisconsin-Madison, USA

pwhewson@wisc.edu

Zena Scholtz

Cape Peninsula University of Technology, Cape Town, South Africa

scholtzz@cput.ac.za

Robert Koopman

Cape Peninsula University of Technology, Cape Town, South Africa

KoopmanR@cput.ac.za

Melanie Sadeck

Cape Peninsula University of Technology, Cape Town, South Africa

sadeckm@cput.ac.za

ABSTRACT

In this paper we document the use of the SCALE Immersion Model for Professional Learning (SIMPL™) to analyse an innovative initial teacher education program for prospective science teachers in South Africa learning to teach argumentation, a designated learning outcome in the national curricula goals of the country (Department of Education, 2002). Data were collected as field notes from observations of teaching sessions and interviews with course tutors. Facilitated reflections using SIMPL helped course tutors separate professional and student learning and realise that student teachers' own comprehension and experience of how to argue had been underestimated.

Keywords: *Argumentation, teacher education, curriculum development*

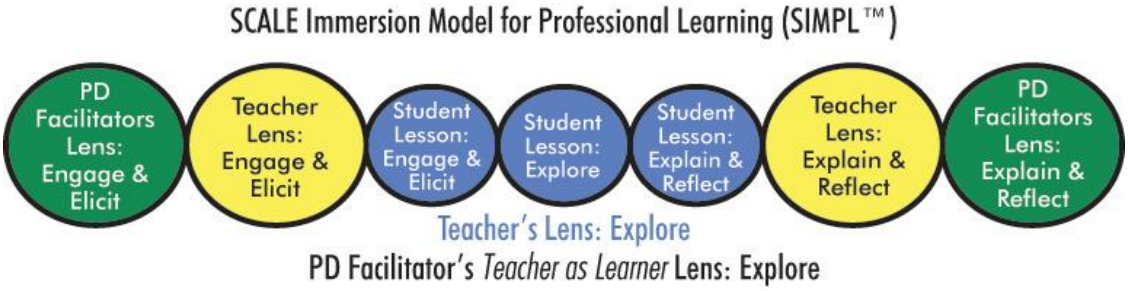
INTRODUCTION

In South Africa, an outcomes based curriculum places critical thinking at the heart of teaching in all subjects. Since argumentation, the process of arguing, has been recognised as a key component of critical thinking (Facione, 1990) and as essential to the development and teaching of ideas and theory in science, the teaching of argumentation in science has received much attention in the scientific community in research and in the development of curriculum materials (Jimenez and Erduran, 2008). So far in South Africa research has concentrated on the nature of teachers' argumentation (Scholtz *et. al,* 2008), learners' argumentation abilities before teaching (Lubben *et al*, 2009) and the different argumentation outcomes of scientific and socio-scientific contexts for lessons (Braund *et al*, 2007). Studies show urgent need for teachers and learners to have better appreciation of what is meant by and required of good quality argumentation in science and technology, the inherent complexities and differences connected with using various contexts for argument and the social, cultural, political, ethical and religious implications of argumentation that are particularly relevant in multi-racial classrooms. Consequently it was recognized that there is a need for teachers entering the profession to be better versed in argumentation and critical thinking and so the focus of research has turned to teacher education.

METHODS

The SCALE Immersion Model of Professional Learning (SIMPL™) was developed in the U.S. to help teacher educators gain new understandings about science and mathematics content and pedagogy in the processes involved in educating future science and mathematics teachers (Lauffer & Lauffer, 2009). Reflections on a semester-long programme on teaching argumentation taught in the final year of a BEd course using SIMPL were carried out to explore how prospective science and technology teachers learn to teach argumentation and what match there might be to components of SIMPL in domains of students', teachers' and PD facilitators' (course tutors) growth in professional learning.

Figure 1. The SIMPL™ Model



Data were collected from two sources: (1) reflective field observations of a semester course on the process and pedagogy of argumentation taught to final year BEd students made by one of the authors who was a fullbright scholar attached to the university and: (2) through recorded interviews with course tutors of science and technology method components of the course. Using SIMPL the study looked for areas of congruence between the module teaching, student outcomes and SIMPL components thus areas in which SIMPL informed the module and its implementation or *vice versa*, i.e., outcomes raised questions about SIMPL. Research was able to comment on the effectiveness of the course at the same time as having facility to critique the validity and applicability of SIMPL in a new setting – South African teacher education.

RESULTS

The application of SIMPL in reflective analysis showed that student teachers need more input in the didactics of augmentation, increased breadth of experience in socio-scientific and scientific contexts in which to develop their argumentation and improved appreciation of class structuring techniques for effective group work. SIMPL proved useful in helping teacher educators appreciate the complexities of their roles and showed a need for and examination of the pedagogy of teacher education that includes more empathy with student teacher learning and recognizes the various lenses of learning involved; for the students, for the school pupils they teach and, most crucially, for the teacher educators.

CONCLUSIONS

The validity and usefulness of SIMPL as an analytical tool for reflective analysis of pedagogical structure and effectiveness of ITE university-based programs in a South African context is supported. As a result of the research, teacher educators are more aware of their multi-level roles in preparation, and diagnosis in ongoing course development and have included more time for student reflection on the development of their argumentation abilities and as contribution to more general construction of their knowledge in earlier years of the degree course. The pay-off for the current cohort of students is better self-awareness of their learning through better appreciation of the value of critical thinking and a willingness to communicate ideas about what teaching for critical thinking and argumentation entails for learners they will teach.

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EMERGING SCIENCE IDENTITIES IN A MENTORSHIP PROGRAM

Lars Brian Krogh

Centre for Science Education, Aarhus University, DK

lars.krogh@cse.au.dk

Hanne Møller Andersen

Centre for Science Education, Aarhus University, DK

hanne.moeller.andersen@cse.au.dk

ABSTRACT

The emergence of students' science identity has been investigated in a university science mentorship program by interviews, questionnaires and observations. The target group consisted of 14 upper secondary school students, all having some inclination towards science and most of them coming from backgrounds far from academic science. Using Late Modern identity theory as a lens, we have constructed and analyzed students' identity narratives. All students in our sample had highly compatible images of scientists and conceptions of themselves. However, their identity process orientations differed and a number of distinct emerging science identities were found.

Keywords: *Science identity, mentorship program, narrative, recruitment*

INTRODUCTION

Danish youth is a clear-cut example of the "Science-is-important-but-I-won't-be-doing-it" trend" emphasized in recent reports (e.g. OECD Global Science Forum, 2004). The intriguing question is how students' general acceptance of the importance of science as an enterprise may lead to internalization of science as part of their personal identity project.

Reports (e.g. (OECD Global Science Forum, 2004)) have been advocating mentoring programmes as a way to facilitate border crossing into S&T paths, providing first-hand-tertiary science experiences, richer and more valid images of science and science careers, as well as relations to useful role-models. The overall aim of our longitudinal project is to study how participation in such a 1½-year mentor program interferes with students' identity processes and may facilitate their emerging science identities and their recruitment to university studies. However, the present work will focus on results from the early phase of the mentorship program. Our research questions here will be:

- Q1 (*descriptive):* What are students' narratives in relation to science and academic education? How do their images of scientists correspond with their characterization of actual and potential Selves?
- Q2 *(analytical):* How can Late Modern identity theory contribute to the interpretation and understanding of student identity narratives in relation to science and academic education?

Theoretically, we subscribe to a Late Modern conception of identity (e.g. Cote & Levine, 2002), where identity is seen as a dynamic narrative of Self (e.g. Sfard & Prusak, 2005). Particularly, we draw on Sfard & Prusak's analytical distinction between *actual* and *designated* identities ("stories believed to have the potential to become part of one's actual identity"). Further, we transcend the identity state description afforded by Marcia's Identity Status Theory (Marcia, 1980) to hypothesize a dynamic description of adolescents' trajectories in and out of science, emphasizing three *Identity Process orientations*: *Exploring, Self-reflecting,* and *Committing*.

METHODS

From a total of 100 mentorship-students we have sampled a diverse target-group of 14 students on the basis of students' written applications to join the mentorship program. A rich empirical database has been gathered, but the present work is based on student interviews and questionnaires. Both interviews and questionnaires focused on students' images of science and scientists, their ideas about future education in relation to science and university, their science related self-efficacy and experiences with science both in and out of school, and the attitudes of family and friends in relation to science and university studies. The interviews were individual, semi-structured and typically lasted for about an hour. The last part of the interview included a simple *"Scientists And Me"* (SAM)-instrument, which was designed to elicit a gap between students' conceptions of scientists and themselves.

All our target-students completed a questionnaire consisting of 76 items, with major parts taken from existing surveys (e.g. attitudinal scales from PISA Science 2006).

Our first analytical step (cf. research question 1) has been to construct and validate narratives for each target student, pursuing our theoretical understanding of identities as narratives. The narratives constructed on the basis of students' self-presentations (interviews, questionnaire) have been triangulated against observations of the students in different mentor program activities. The SAM-data has been analyzed separately, and significant features have been built into students' narratives. Draft narratives were member-checked with the participating students.

Following this step we have analyzed students' narratives in terms of categories from identity theory, e.g. to establish their actual/designated identities in relation to science and how *Exploring*, *Committing* and *Self-reflecting* students are in educational choice related life-domains, including science.

RESULTS

We have found students' narratives to be rich and multi-facetted. Illustrations of this and the nature of narratives will be given at the presentation. The "potential scientist" status of students in our sample is evident from consistent patterns of the SAM-analysis. Even though the sample is more homogenous than samples in other science identity studies we have identified significant differences among emerging science identities. Table 1 indicates two examples of emerging science identities in terms of our theoretical lenses (Actual Identities (ai) and Designated Science Identities (di) and dominant Identity Process-Orientations (ipo))

Table 1. Sample emerging science identities through theoretical lenses

T (boy) has an interest in Math, Science and Technology (MST) (ai), and he wants a MST-education, but he is uncertain about going to the university (di). T sees scientists as nerds as well as interesting persons, because of their specialist knowledge. He experiences no serious gap in taking on a MST scientist identity. T is oriented towards *Exploring*. He is easily inspired by new information and he is willing to change his ideas about the future if something new seems challenging (*no commitment*). He is rather *reflective* in his description of his life, both concerning his per sonal characteristics and possibilities	**F** (girl) has an interest in math and science – as well as several other subjects (ai). F plans going to university (di), but she is uncertain about what she wants to study. F sees scientists as curious and innovative, and she finds it interesting to listen to their stories. She thinks that scientists work collaboratively, but ascribe them low political and social interest, which may prevent her from choosing science (di). F's is oriented towards *reflecting* and social relations. She is highly influenced by ideas and recognition from significant others (parents and teachers). She is not *Committing herself* in relation to future job or education, and is not seriously *Exploring.*

CONCLUSIONS

The students of our study typically have varied and low-stereotyped images of scientists, and the overlap between students' actual and designated science identities are considerable. Science indeed is a potential identity-story for this group of students, though some value-differences have been identified, that may ultimately lead students away from science trajectories. Students' narratives have been analyzed in terms of their orientation towards the identity-processes *Exploring, Reflecting,* and *Committing* in life-domains of relevance for science. It is hypothesized that these orientations will critically and differentially impact students' response to the mentorship program and their ways in or out of science. Another question is how external affordances and incentives from the mentorship program and school science facilitate *Exploring* etc. We will know more as our study proceeds.

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USAGE OF METACOGNITIVE PROMPTS IN A SCIENCE LABORATORY COURSE

Birgül Çakır

Department of Elementary Education
Agri İbrahim Çeçen University
Agrı/Turkey

cbirgul@metu.edu.tr

Hamide Ertepınar

Department of Elementary Education
Middle East Technical University
Ankara/Turkey

hamide@metu.edu.tr

Özgül Yılmaz Tüzün

Department of Elementary Education
Middle East Technical University
Ankara/Turkey

ozgul@metu.edu.tr

ABSTRACT

The purpose of this study was to determine the preservice science teachers' (PSTs) metacognitive processes by using metacognitive prompts in a science laboratory course. The data were obtained through PSTs' laboratory reports which contains metacognitive prompts and PSTs' models developed based on their observations and inferences. PSTs were formed 8 groups each included 3 to 4 students and two groups were randomly selected for the analysis of this study. The data were analyzed through qualitative methods. It was found PSTs, who activated their procedural knowledge, constructed effective models which enabled them to carry out necessary investigations during the laboratory activities.

Keywords: *metacognition, metacognitive prompts, preservice science teachers*

INTRODUCTION

Metacognition is the ability which provides one to understand and monitor the cognitive processes (Zimmerman, 1989). Two basic types of metacognition are executive management strategies for planning, monitoring, evaluating and revising one's own thinking processes and products, and strategic knowledge about what information and strategies/skills one has (declarative), when and why to use them (contextual/conditional) and how to use them (procedural) (cited in Hartman, 2001; Flavell,1987).

Use of metacognition is necessary for learning since metacognitive knowledge and strategies have important roles in thinking, reasoning and problem solving. Although the studies on metacognition show that metacognition has an important role on learning, many srudents are unaware of their thinking processes, strategies and their thinking products. (Driver, Newton & Osborne, 2000).

In this study metacogvitive prompts are used. Prompts are questions that encourage students to add more details and ask for thinking deeply to evoke metacognitive skills (Peters, 2008). These prompts help students to write their metacognitive reflections which includes their learning process, strategies, comprehension levels, their success or failure in their tasks and the evaluation of their performance (Bangert-Drowns, Hurler & Wilkinson, 2004). Therefore, prompts were given students to evoke their metacognitive skills.

METHOD

The participants were preservice science teachers who attended an inquiry based laboratory application course in a large public university in Ankara, Turkey. Totally 29 PSTs took this course and they worked as a group of 3 or 4. Of these groups, 2 groups were selected randomly to for the purpose of this study. Since each of these two groups included 4 PSTs, 8 PSTs constituted the particpants of this study. All PSTs in this study were 3rd graders and they took the same background lessons. The data were obtained through the PSTs responses to the laboratory reports, which included metacognitive prompts. 6 activities were covered throughout the course and an activity was selected to focus for this study. This activity's name was black box which was designed by Lederman and Abd-El-Khalick (1998). For this study metacognitive prompts and model request were added to this activity. Through developing a model the researchers tried to understand alternative working models of the black box that appear on particpants' minds during the activity.PSTs' strategies for designing their own model and their knowledge of cognition were examined with respect to metacognition.

The analysis was made through content analysis techniques as one ofthe qualitative analysis techniques. For this purpose PSTs' written responses to laboratory methods were examined with respect to content.

PROCEDURE

Balack box activity provides students to make observations and inferences. It is a closed box and there was a system in it which provides more liquid than one added (Lederman & Abd-El-Khalic, 1998). In this study, PSTs drew their own model individually depending on their observations and inferences. The purpose of this activity was the distinction between observation and inference, the importance of subjectivity, creativity in science. The activity was completed in three hours.

RESULTS

Answers for observation and inference:

Some examples for observations from their answers are: *200 ml transperant liguid is poured from the top of the box and 550 ml homogenous transparent liquid is taken. Box have one entrance from the top and one exit wit a pipe in the bottom.*
Some examples for inferences from their answers are: *There are some liquid in black box. There is a system in the box which is designed for the release some amount of liquid.*
Examples show that students know the differences between observation and inferences.

The prompt for observation and inference was "What do you coclude about the value of observations and inferences in the scientific method?" Duygu wrote that *"In order to make hypothesis, observations and inferences are important for science. Scientists use observation to make their inferences and make prediction with using their inferences. They make hypothesis by using their prediction."* In terms of metacognitive statements, she explicitly refers her undertsanding and knew why to use observations and inferences. It shows that she used conditional knowledge. Students knew the difference but they did not refer how they make inferences and how scientists make inferences.

Prompt for their models is that "What experiences gave you ideas to help you make sense of your model?" The question requires procedural knowledge which is a type of cognition of knowledge in metacognition. PSTs who activated their procedural knowledge wrote those answers. Burcu wrote that "*the rivers flow due to the potential difference . In my model, I tried to create a big potential difference between 2nd beaker and the hole, so it caused the flow of water from the hole".* Mehmet wrote that *"Im inspired by the work of dam that so much amount of water is activated by opening of barier. Because water which is behind the barrier pushes the water in dam after barrier open. Here, I thought opening of barrier as tearing of paper. Increasing pressure both of two event leads flowing huge amount of water."* Esra draw a model based on her chemistry knowledge and wrote that: *" In chemistry labs, I observed* *the elements which are solving eachother while the others do not solve. In this model, I thought that there is a material which is solved with water and is not solved with colorless liquid."* These students' models were logical and capable of work. On the other hand, there are other students who did not activate cognition of knowledge. These students' models were not capable to work. Aslıhan was one of them and wrote that *"my previous knowledge and physics and chemistry lessons help me make sense of my model."* She did not refer any metacognitive statement in her answer. As a result, PSTs are aware of the differences between observation and inference but most of them did not aware of the metacognitive skills. It is also concluded that PTSs who activated metacognitive skills created models that are capable to work.

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VIRTUAL COURSEWARE IN HIGH SCHOOL BIOLOGY CLASSROOM: DROSOPHILA LAB

Mustafa Cakir
Marmara University
mustafacakir@marmara.edu.tr

Selen Karaagac
Bostanci Doga High School
selenkaraagac@gmail.com

ABSTRACT

Teaching Mendelian genetics to high school students is rather a complicated process that requires a diligent planning and appropriate materials. The aim of this study was to use virtual courseware in order to implement an inquiry-based genetics teaching. A teaching unit that required students to design experiments and collect, analyze data, and test hypothesis was designed. A "Drosophila" lab from Virtual Courseware for Inquiry-based Science Education was used in pretest-posttest control-group experimental research design. It was concluded that an inquiry-based teaching method with "Drosophila" simulation is possible, beneficial, and has a potential to support conceptual learning of principles of inheritance.

Keywords: *Mendelian genetics, virtual courseware, inquiry-based teaching.*

INTRODUCTION

The use of learning technologies to support students in developing conceptual understanding of a specific subject-matter is a viable use of technology. Learning technologies can also be used to enhance some of the cognitive processes that have been associated with inquiry in science, including generating ideas, coordinating ideas with evidence, evaluating findings, and weighing alternative explanations. One area of biology in which students have difficulties is genetics (Johnson & Stewart, 2002). Most school textbooks introduce Mendelian genetics and the discussion of mathematical models of transmission patterns. A survey of high school teachers (Stewart, 1982) indicated that Mendelian genetics, meiosis and mitosis, and the chromosome theory of inheritance were considered among the most difficult as well as the most important topics of study for high school students. This research focuses on high school students' learning in Mendelian genetics using computer simulation.

By examining learning processes of students as they interact with computer simulation, and the guidance strategies that facilitate their learning in this study, we may be able to gain some insights into how to feasibly integrate computer simulations into high school biology classrooms in order to enhance meaningful and conceptual learning.

THEORETICAL BACKGROUND

Perspectives from social constructivist and socio-cultural views of learning shaped this study (Vygotsky, 1978; Wenger, 1998). According to this line of thinking, science learning can be viewed as a participatory process that includes the negotiation of the cultural practices of scientific communities. These cultural practices include constructing explanations, defending and challenging claims, interpreting evidence, using and developing models, transforming observations into findings, and arguing theories. In this framework, learning is regarded as a participatory process in which the learner gradually becomes an active member in a cultural community by learning its discourse practices, norms, and ways of thinking (Wenger, 1998).

Hypothesis testing has recently been presented very positively within the science education community, being promoted as a powerful context for supporting knowledge acquisition in science (Howe et al., 2000). The drive has come from reform documents, which emphasize the integrated acquisition of conceptual and procedural knowledge. Because hypothesis testing provides context where students can formulate conceptual knowledge into researchable ideas, investigate ideas through manipulation, prediction, and observation, and evaluate ideas in the light of evidence, in principle, should allow integrated acquisition of knowledge.

METHODS

"Drosophila" is an interactive, online simulation which was developed in Virtual Courseware for Inquiry Science Education project and designed to enhance traditional high school biology curricula by providing supplements to experimental laboratory in California State University. Students make observations, propose hypotheses, design experiments, collect and analyze data generated by the simulation. Drosophila Lab allows the recording of observations, data, and results. This is manifested as a built-in electronic notebook or journal. Thus, the online user interface exhibits the entire process of science from discovery, to analysis, to reporting.

Pretest-posttest control-group experimental research design was adopted in this study which was conducted in Bostancı Doga High School. There were total of 88 high school students in two experimental and two control group classrooms. Two experimental group classes received inquiry-based teaching with VCISE program and two control group classes received traditional lecturing. Unit was completed in 8 hours of instruction. All tests and questionnaires were given to all participants. Students were assessed using pre- and post-tests and concept maps. Additionally, participants were given another general test for grading purposes. Students were also given surveys to measure their learning preferences and evaluate their own learning. Appropriate statistical methods employed in data analysis.

RESULTS

There was not any statistically significant difference between pre-test scores of experimental and control groups. However, a statistically significant difference detected between post-tests of experimental and control groups. In addition to posttest, an academic achievement test which consisted of classical paper and pencil items was also administered to all groups for grading purposes. There was statistically highly significant difference between the means of achievement test scores of experimental and control groups. Qualitative analysis of concepts maps and student interviews revealed important findings. Concept maps of experimental group received higher grades as they were more structured and hierarchically correct and included more concepts and linkages. Concept maps, posttest, and achievement test scores were highly correlated. Inquiry-based learning experiences with virtual courseware, Drosophila, not only facilitated conceptual genetics learning but also provided an excellent opportunity for students to develop inquiry abilities such as hypothesis testing and experimental design.

CONCLUSIONS

It was concluded that an inquiry-based teaching method with “Drosophila” simulation is possible, beneficial, and has a potential to support conceptual learning of principles of inheritance. In our contribution we will report our results and describe instructional measures and scaffolds that rendered inquiry teaching effective. Drosophila software has “Notebooks” where students could take notes about their hypothesis and inquiry. Analysis revealed that students barely used notes to reflect on their own learning process. They rather haphazardly followed the instructions and did not really engage cognitively in the process. The importance of systematic note taking and data recording was emphasized. Interpreting their own experimental outcomes served as instructional scaffold in their conceptual development.

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AXES OF VALUES IN HEALTH EDUCATION: IDENTIFICATION, CHARACTERISATION AND APPLICATION TO STUDENTS OF SEVEN UNIVERSITY COURSES

Graça S. Carvalho

CIFPEC, Institute of Education
University of Minho
Braga, Portugal

graca@ie.uminho.pt

Amâncio Carvalho

Nursing School
UTAD
Vila Real, Portugal

amanciocarv@hotmail.com

ABSTRACT

Education carries inexorably the notion of values to be transmitted, often expressed in an implicit way (Reiss, 2007). Being health a matter of social and individual challenges, health education (HE) is a process involving strongly the education for the values. Schools must assume this role of education for the values and should also identify their students' conceptions. Thus, the general aim of the present study was to identify the system of values manifest, explicitly or implicitly, in national and international publications. Six axes of values were identified: Social–Individual, Salutogenic–Pathogenic, Holistic–Reductionist, Equity–Inequity, Autonomy–Dependence and Democratic–Autocratic. To know how different university courses in the area of health (medicine and nursing), pre-school teaching, basic teaching and social service highlight these axes of values, we applied a questionnaire to 709 students of the above seven courses. Particular attention was given to the course of nursing located in Vila Real (E-VR). Results showed that the E-VR teaching modules programmes and the corresponding teaching documents refer almost solely the Salutogenic/Pathogenic axis, minimising all the other five axes of values. Having in mind the effects of the training courses in student's values and conceptions about health education and health promotion (HE/HP), this study reveals that in most courses (including E-VR) more emphasis should be given to the social aspect and the salutogenic perspective of HE/HP.

Key words: *Health education, Values, University training.*

INTRODUCTION

According to the World Health Organisation (WHO, 2000), governments have the responsibility to promote their citizens' health. In order to fulfil this aim they should guarantee that the professionals of all sectors acquire appropriate knowledge, attitudes and competences to protect and promote health (WHO, 2008). Besides, no educational plan should avoid values, since they are the elements that shape up most people's choices (Vallejo, 2002). For that, universities must assume this role of education for the values and should also identify their students' conceptions. Thus, the general aim of the present study was to analyse the evolution of students' values and conceptions about health education (HE) and health promotion (HP), through their university training. These students were enrolled in the 1st and 4th year of university courses: four courses in the field of health (1 of medicine and 3 of nurse practitioners) and three in social/educational studies (social service, pre-school teaching and basic school teaching). Particular attention was given to the course of nursing located in Vila Real (E-VR). To carry out this evaluation, it was created previously a theoretical framework concerning the axes of values on health education, which was constructed by content analysis of research papers and international organisations documents.

METHODOLOGY

Theoretical framework on axes of values on health education

Content analysis was carried out in a total of 129 documents: in 66 papers from research authors (46 books and chapters of books and 20 papers in journals); in 30 official documents from international organisations (8 from the WHO, 5 from the European Commission and 17 from the International Council of Nurses); in 33 Portuguese organisations (5 from the government, 8 from the Ministry of Health, 8 from the Ministry of Education, 6 from the Ministry of Science, Technology and Higher Education, and 6 from the Nurses' professional body).

The axes of values emerged from the analysis of health education documents, by using the method of "ground theory" (Strauss & Corbin, 1998) were applied to the analysis of texts used at one of the university courses of nursing (E-VR) and for the preparation of the questionnaires to be applied to the university students of the seven courses analysed in this study.

Theoretical framework on axes of values on health education

A questionnaire was constructed and validated after a pilot test (Carvalho & Carvalho, 2006). The population size was 1132 students (year 1 and year 4) and the sample was composed of 709 students (62.6% of the population) of seven university courses: E-VR – Nurses from Vila Real (UTAD); E-BR – Nurses from Braga (UM); E-PO – Nurses from Porto (IPP); MED – Medicine from Porto (UP); PEB – Primary school teachers (UM); EI – Kindergarten educator (UM); SSO – Social services (UC-B).

RESULTS

Theoretical framework on axes of values on health education

Through the content analysis of health education and health promotion (HE/HP) documents we identified a set of six axes of values in HP/HE: Social–Individual, Salutogenic–Pathogenic, Holistic–Reductionist, Equity–Inequity, Autonomy–Dependence and Democratic–Autocratic.

Asking students of the seven courses to express in single words their ideas about health, the key words emerged were (by decreasing order): Well-being, Hospital, Disease, Doctors and Nurses. The predominance of these key words is connected to a reductionist vision of the health determinants, centred in the system of health, excluding the other ones.

When looking at the evolution of the concept of health from the 1st to the 4th year of university training, the Braga Nursing course (E-BR) was the one with higher decrease in the key words associated to the reductionist vision of the term and, similarly, the course of Basic Teaching Teachers (PEB) was the one with more increases associated to the wide concept of health.

In contrast, the nursing course from Vila real (E-VR) did not show substantial changes on the perspective of health, keeping the technical-centric view of health along training. Training showed to strengthen the construction of a wider HP concept in the E-VR and in the Porto Nursing course (E-PO), with highly significant differences (χ^2: p=0,000) from the 1st to the 4th year. The majority of the sample (87%) considers that HE has values to promote; being the concept responsibility the most indicated one.

Taking together all samples it was possible to verify that the training caused statistically significant evolution on the conceptions in the following three axes: from pathogenic to salutogenic; from reductionist to holistic; and from autocratic to democratic. No changes were found in the axes social/individual, equity/inequity and autonomy/dependence.

A general tendency towards the positive poles of the values axes was found in most sub-samples: the highest scores were found in the courses E-BR and Medicine (MED) whereas the smallest means were in the Social Service course (SSO).

CONCLUSIONS AND IMPLICATIONS

The university (E-VR) teaching modules programmes and the corresponding teaching documents refer almost solely the Salutogenic/Pathogenic axis, minimising all the other five axes of values. The present study demonstrates that changes in the programmes should be made in order to follow the international guidelines on HE/HP.

Having in mind the effects of the training courses in student's values and conceptions about HE/HP this study reveals that more emphasis should be given to the social aspect of HE/HP (in E-VR, E-PO, MED, PEB, EI and SSO), to the salutogenic perspective (in E-BR, E-PO, PEB, EI and SSO), to the holistic view of health (in EI), to the Equity in health (in E-VR, E-PO and EI) and to autonomy and democracy (in MED and EI).

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WHAT I WANT TO LEARN ABOUT PHYSICS TOPICS: A GENERAL PICTURE OF TURKISH ROSE SURVEY

Bulent Cavas

Dokuz Eylul University

bulent.cavas@deu.edu.tr

Hulya Yılmaz

Ege University

hulya.yilmaz@ege.edu.tr

Pınar Cavas

Ege University

pinar.huyuguzel@ege.edu.tr

Teoman Kesercioglu

Dokuz Eylul University

teoman.koglu@deu.edu.tr

ABSTRACT

This study aims to explore Turkish ninth grade students' interests in learning physics topics and physics-related out of school experiences in terms of gender differences. The questionnaire-based Relevance of Science Education (ROSE) Project data of 9th grade students were collected in Turkey from 1,260 students. Statistical analysis included tabulation of frequency distribution, descriptive statistics, MANOVA and correlation analysis. The findings of this study revealed that Turkish students are interested in learning physics topics, but they have little out of school experiences related to physics. Several significant gender differences were found. Based on the findings, the implications for physics education will be discussed.

Keywords: *Interests, out of school experiences, physics topics.*

INTRODUCTION

Many studies have been conducted on students' behavior, interests and attitudes toward science / physics (Sjoberg, 2000; Osborne, Simon & Collins, 2003) in the last 20 years. Pupils' interests in Physics from ROSE study also researched by Lavonen et al. (2005, 2008) and Trumper (2006). According to literature on the students' interest in physics context, girls mean scores were typically lower than boys. However, it is found that girls are more interested than boys in phenomena that is not explained by school physics, and nature values and environmental responsibility (Lavonen, et al., 2005; Hoffman, 2002; Cavas et al., 2009) The main message from ROSE based studies tell us that it is important to re-design curriculum combining interesting science topics. This concern is vital not only for lasting scientific endeavor but also for sustaining scientific literacy. The aim of this study is to investigate Turkish ninth grade students' interests in learning physics topics and physics-related out of school experiences regarding gender.

METHOD

In this study, a comparative study's questionnaire, ROSE (Relevance of Science Education), was used as a data collection tool. ROSE questionnaire is a Likert-type scale and "What I want to learn about" "My future job", "Me and the environmental challenges", "My science classes", "My opinion about science and technology", "My out-of-school experiences" and "Me as a scientist requires students" sections. In this study, we used 29 items related to physics topics from "What I want to learn about" section and 21 items related to out of school experiences in physics from "My out-of-school experiences" section of the ROSE questionnaire. Students' interests in learning physics topics were analysed into four contexts categorized by Schreiner and Sjoberg (2004). These contexts are "*Astrophysics & Universe (AU)*", "*Light, Colours and Radiation (LCR)",* "*Sounds (S)"* and "*Energy and Electricity (EE)"*. The sample of this study includes 680 girls and 580 boys enrolled at ninth grade of the 63 high schools from 21 cities which are located at seven different geographic regions in the 2003-2004 teaching semester. The national average school age of the students is 15 years.

RESULTS

In order to evaluate the reliability of the sub-scales, we calculated Cronbach's Alpha (α) for each scale. The reliability coefficients for the "What I want to learn about Physics" and "My out-of-school experiences" scales were found as 0.88 and 0.83 respectively. Mean scores and standard deviations for girls, boys and overall can be shown at Table 1.

Table 1. Descriptive Statistics for Students' Interests Scores

	Girls		Boys		Total	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
Astrophysics & Universe (AU)	3.17	0.58	3.03	0.63	3.11	0.61
Light, Colors and Radiation (LCR)	2.86	0.56	2.78	0.61	2.82	0.60
Sounds (S)	2.83	0.76	2.73	0.75	2.78	0.75
Energy and Electricity (EE)	2.74	0.73	2.98	0.62	2.85	0.70
Total (AU, LCR, S, EE)	**2.96**	**0.49**	**2.90**	**0.53**	**2.93**	**0.68**
Out of school experiences	**2.05**	**0.47**	**2.40**	**0.52**	**2.21**	**0.52**

Results indicate that students' interests in learning physics topics are at a moderate level (M= 2,93, SD= 0.68). Students show more interest in learning astrophysics and universe subjects than other topics. Interestingly, girls are more interested in learning physics topics than boys except one topic (energy and electricity). Students' out of school experiences related to physics topics are analyzed in terms of gender. Generally mean scores of out of school experiences in physics for both girls (M=2.05) and boys (M=2.40) are under middle of the scale (2.5). Students only have several experiences in using binoculars and camera, measuring the temperature with a thermometer and using a measuring ruler, tape or stick. They had little experience in charging a car battery, using mechanical devices like a windmill, watermill, and waterwheel, compass and visiting informal science settings like science centers or museums. In order to find differences between girls and boys' mean scores of interests and out of school experiences in terms of physics topics, one-way MANOVA was utilized. Significantly differences were found in both students' interests in learning different physics topics and out of school experiences related to physics (Wilks' Λ= 0.81, $F(1,1258)=58.51$, $p=0.000$, partial eta squared= .189). While girls have higher mean scores than boys in learning AU, LCR and S, boys are more interested in learning EE and experienced in physics. There is also a significant small but positive relationship between students interests in learning physics topics and physics-related out of school experiences ($r=.288$).

DISCUSSION

It is well known fact that students' interest and experience affect their motivation and success in learning. Therefore all teaching activities should be designed regarding these factors. However, there is a important gap between what is learned in the classroom and the real life context of the pupils' present or future world (Anamuah-Mensah and Towse, 1995; Stevenson, 1995 and Muskin, 1997, cited in Anderson, 2005). Like many others, our study also show that both girls and boys are very interested in learning physics topics but they have no chance to experience physics-related out of school activities. In order to solve this problem, science curriculum or context should be developed taking into account students' out of school experiences.

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PROSPECTIVE EARLY CHILDHOOD TEACHERS' VIEWS OF NATURE OF SCIENCE AND SCIENTIFIC INQUIRY

Shu-Min Chen
National Pingtung University of Education
shumin@mail.npue.edu.tw

Ching-Yi Chang
Tajen University
ccy@mail.tajen.edu.tw

Huey-Lien Kao
National Pingtung University of Education
hkao@mail.npue.edu.tw

ABSTRACT

This study investigated prospective early childhood teachers' conceptions of nature of science (NOS) and scientific inquiry (SI). The participants comprised 119 undergraduate students enrolled in an early childhood education program in a university in southern Taiwan. Two open-ended questionnaires, coupled with individual semi-structured interviews, were used to separately assess the participants' views of NOS and SI. The results indicated that almost all the participants possessed inadequate conceptions of NOS and SI.

Keywords: *nature of science, prospective teacher, scientific inquiry*

INTRODUCTION

Scientific literacy for all citizens is an important goal of science education in many countries, and developing an adequate understanding of the nature of science and scientific inquiry is a key element in achieving this goal.

METHODS

This study comprised 119 undergraduates studying early childhood education in a university in southern Taiwan. Two open-ended questionnaires were used to independently assess the participants' views of NOS and SI. Semi-structured interviews further established the face validity of the questionnaires by ensuring that the researchers' interpretations corresponded to those of the participants.

RESULTS

The results revealed that very few of the participants possessed adequate conceptions of all aspects of NOS and SI. However, compared to those in previous studies (e. g., Liu, & Lederman, 2007) the majority of participants in this study evidenced inadequate conceptions of most target NOS and SI aspects.

CONCLUSIONS

Since teachers' conceptions of NOS and SI may influence their teaching practices, the present results indicate a need for prospective early childhood teachers to develop a better understanding of the nature of science and scientific inquiry.

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SCIENCE EDUCATION IN CONTEXT OF REQUIREMENTS OF CURRENT SOCIETY

Vera Cizkova

Charles University in Prague Faculty of Science

veciz@natur.cuni.cz

Hana Ctrnactova

Charles University in Prague Faculty of Science

ctr@natur.cuni.cz

ABSTRACT

Science contains some very important disciplines that contribute to the further development of our society. We focused on the problem of creating of contents and educational methods of science subjects which will help to improve the pupils' interest in these subjects and to increase the effectivity of their teaching.

This contribution informs about the solution of this problematics in the national and European projects aimed, among other, to increasing the interest on primary and secondary school pupils in science via interesting contents, current themes emphasizing their practical applicability and use of new activizing methods of these fields, especially the inquiry-based science education.

Keywords: *primary and secondary schools, science subjects, key and specific competences, science literacy*

INTRODUCTION

The turn of century's international comparative studies in science education showed that the young people have much less interest in studying science. For example, the pupils of primary and secondary schools in most of the countries of Europe and beyond, don't have much interest in the science education and subjects like physics and chemistry are actually the least favorite subjects in the long term on these schools. The way science is being taught in schools is justifiably considered one of the main cases of the dropping interest (Abd-El-Khalick, 2005). Experts are trying, as part of their national and international projects, to stop this situation; their goal is to analyze the current national initiatives in a given field and get know-how elements that could cause a substantial change in young people's interest in studying science and that could be transferrable and usable in the educational systems of other countries from the representative sample of these initiatives (European Commission, 2007). The main focus is on inquiry-based science education – IBSE, which, according to what we know so far, proved its effectivity in both primary and secondary education – not only did the pupils' interest increase, but so did their results, and so was improved the teachers' motivation (Sherwood, 2007). IBSE was found effective for all groups of pupils, from the least to the most capable, according to their effort to be the best. In addition, IBSE turned out to be beneficial for support of girls' interest in scientific activities. The fact that IBSE and the traditional pedagogical approaches are not contrary and can (and should be) mixed in the science education in order to adjust the teaching to pupils' various ways of thinking and age preferences is also important (European Commission, 2007). These reasons became the starting point for solving this problematics at the Faculty of Science and Faculty of Mathematics and Physics at the Charles University. This was done in a structured way, in the frame of both national and European project.

METHODS

The main goal of the projects is to increase the interest in and the effectivity of the science education at primary and secondary schools with the help of interesting contents, current themes emphasizing their practical applicability and new activizing educational methods, especially IBSE.

The starting point of the project solving was the analysis of strategical and curricular documents of CR and EU (Čtrnáctová et al., 2007), the results and recommendations of the international projects TIMSS and PISA, of the projects Pollen (http://www.pollen-europa.net/) and Sinus-Transfer (http://sinus-transfer.uni-bayreuth.de/), and the results of national projects solved in 2005-08 with the support of ESF (Čtrnáctová et al., 2007; Řezníčková, 2009; Straková et al., 2006). At the same time we have performed a questionnaire survey to find out the current state of science education and the needs of their teachers at the primary and secondary schools in the Czech Republic.

The results of the analysis of said documents and the questionnaire survey were the theoretical starting points for the further project activities in the lines of various scientific subjects. These activities aim to improve the teaching quality by innovation and actualization of the educational programmes as well as the methods of teaching based on pupils' practical activities and a problem approach with their realizations in specific school conditions. The emphasis is put on the development of key and field competences, on the development of the higher-order intelectual skills of the pupils, especially the critical thinking, creativity and self-reflection. Thanks to the methods that use active approach of pupils, other key competences are also developer. The project activities are resting on creating, verifying and realizing the thematically aimed modules from the subjects of biology, chemistry, physics and geography at the primary and secondary schools.

RESULTS

The chosen methods were gradually applied to selected themes in solved national projects simultaneously with the creation of specific educational materials for various educational fields and cross-section themis, in total, 40 educational materials were created. Gradually, 82 primary and secondary schools, 168 science teachers and 3,482 pupils joined the project. The educational materials were continuously being made available to the science teachers who gradually verified them in the school practice and evaluated them. The evaluation tools were mainly questionnaire surveys, as well as tests and directed interviews. All the teachers evaluated them very positively – they especially prized their immediate benefit for their own pedagogical work and for the improvement of the quality of science education at primary and secondary schools.

During further solving of this problematics, further study and methodical materials will be created for each modul, based on IBSE, and selected teachers will be trained to realize them. As part of project solving there will be 10 months of lessons based on the created and pilot-verified modules at selected primary and secondary schools. Its effectivity will be evaluated at the final stage of the project.

CONCLUSIONS

Although the inquiry-based science education is generally acknowledged and recommended because of its clear advantages, the results from the real world show that it's still relatively underused in the school lessons. However, it's not just because of the greater time demands, but also, and probably more often, in the lack of availability of the resources, specific themes and problems. Another important cause of the low level of inquiry-based education usage is the conviction of certain teachers that the traditional way of education gives the necessary knowledge to the students much more effectively.

This is why further research has to focus on the experimental checking of teaching effectivity of inquiry-based education, both in short-term and long-term, especially long-term. The existing research was so far mostly theoretical, the specific, experimentally verified research is rare and in biology and chemistry it's practically nonexistent. We think that this is the direction our research has to take in the future. The specific possibility of its realization is currently available due to the ESTABLISH project that started in 2010 which we are solving together with other coworkers from 14 institutions in 11 European countries.

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TEACHERS' CONCEPTIONS ON ENVIRONMENT AND GMO IN TWELVE EUROPEAN COUNTRIES

Pierre Clément
University Lyon 1, France,
Pierre.Clement@univ-lyon1.fr

Jérémy Castéra
University Lyon 1, France,
jeremycastera@gmail.com

Charline Laurent
University Lyon 1, France,
Charline_la@yahoo.fr

Silvia Caravita
CNR, Roma, Italy,
silvia.caravita@istc.cnr.it

Anna-Liisa Rauma-Kosonen
University of Joensuu, Finland,
Anna-Liisa.Rauma@Joensuu.fi

Attila Varga
National Institute for Public Education, Hungary,
attila.varga@ofi.hu

Jurga Turcinaviciene
University of Vilnius, Lithuania,
jurga.turcinaviciene@gf.vu.lt

Elwira Samonek-Miciuk
University of Lublin, Poland,
elsami@biotop.umcs.lublin.pl

Adrienne Kozan-Naumescu
Babes-Bolyai University Cluj, Romania,
kozanadrienne@yahoo.com

Paul Pace
University of Malta, Malta,
paul.j.pace@um.edu.mt

Kai Pata
University of Tartu, Estonia,
pajulind@hotmail.com

Nicos Valanides
University of Cyprus, Cyprus,
nichri@ucy.ac.cy

Franz Bogner
University of Bayreuth, Germany,
Franz.Bogner@uni-bayreuth.de

Graça Carvalho
IEC, University of Minho, Portugal,
graca@iec.uminho.pt

ABSTRACT

We analyze the conceptions of 4248 teachers on Environment and GMO (Genetically Modified Organisms), in 12 European countries: Cyprus, Estonia, Finland, France, Germany, Hungary, Italy, Lithuania, Malta, Poland, Portugal, Romania.

Most of the differences between teachers' conceptions are observed inside each country. Some of them (related to preservation or utilization of Environment) significantly differentiate the 12 countries. Biology teachers have more knowledge on GMO and more opinions pro-GMO than their colleagues. Female teachers are significantly more anti-GMO than their male

colleagues. More a teacher studied at University, more he or she thinks that the resources of our planet are limited.

Keywords: *Environmental Education, GMO, teachers, conceptions, values, Europe.*

INTRODUCTION

The acceptance or reject of GMO (Genetically Modified Organisms) is a controversial issue in the European Community, with an opposition of divergent scientific arguments generally linked to different opinions (Berlan & Lewontin 1986, Kempf 2003, Bonneuil *et al*. 2008). These opinions are often rooted in philosophical points of view on Nature and on Environment, associated with divergent values (Schultz & Zelezny 1999, Clément 2004a, 2004b). In a broader way, the importance of values in science education is re-emerging (Corringan, Dillon & Gunstone 2007), and values are not exactly the same among the European countries (Galland & Lemel 2007). According to European Commission public opinion survey (Eurobarometer, 2008), the majority of Europeans are opposed to the use of GMOs (58%). At the country level the resistance is more important in some countries as Cyprus (82%) than in other ones as Malta (28%) or Portugal (28%).

What are the teachers' conceptions related to GMO in different European countries? Are their conceptions linked to their philosophy and attitudes on Nature and Environment? Are they linked to their scientific knowledge, or mainly to their values? Are there differences among countries, or among other teachers' characteristics (as their age, gender, level of instruction)?

METHODS

Twelve European countries were chosen from their diversity, from North to South and East to West of Europe, from diverse economical levels and cultures, including differences among their religions: Cyprus, Estonia, Finland, France, Germany, Hungary, Italy, Lithuania, Malta, Poland, Portugal, Romania. In each country, six samples of about 50 teachers filled out a questionnaire: in-service teachers in primary schools (InP), in-service teachers in secondary schools teaching biology (InB) or language (InL); pre-service teachers for primary schools (PreP), pre-service teachers for secondary schools in biology (PreB) or language / letters (PreL); for a total of 4248 teachers in the 12 countries.

Each teacher filled out a questionnaire built by a collective work of the European research project Biohead-Citizen (Biology, Health and Environmental Education for better Citizenship, 2004-2008). Our theoretical basis and our methodology are described in other works (Caravita *et al*., 2008; Clément & Carvalho, 2007). We used several precautions: a pilot test, interviews, avoiding bias in translation, etc. The final questionnaire (144 questions) included 29 questions related to Environment, 5 of them dealing with GMO. The teachers' answers were discussed using multivariate analyses (Munoz *et al*., 2009): mainly PCA and between analyses completed by randomization tests (Monte Carlo type).

RESULTS

* The PCA (Principal Components Analysis) shows the main oppositions among the 4248 teachers' conceptions: the first one between the poles preservation and utilization of environment, with some link between preservation and anti-GMO opinions, and between

utilization and pro-GMO opinions. The second opposition is related to the "feelings" of animals: being ecolocentric (pole preservation) or anthropocentric (pole utilization), a teacher can think that snails, flies and frogs are or not able to feel happiness. The third principal component is mainly defined by the 5 questions related to GMO, with a clear opposition between the pole anti-GMO and the pole pro-GMO.

* A between analyses shows that the teachers' conceptions differ very significantly ($p < 0.001$) among the 12 European countries, mainly from the questions related to preservation or utilization of Environment. For instance, more than 80% of teachers are, in Lithuania, confident with the society to solve even the biggest environmental problems, while this percentage is about 1/3 in Finland and Poland, but less than 10% in the other countries.

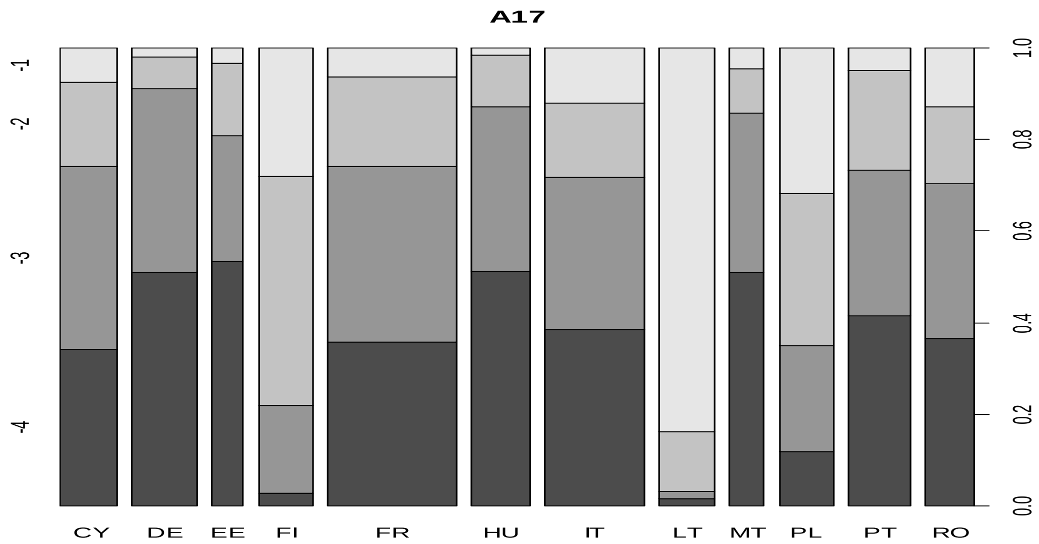

Figure 1 - Answers of teachers to the question A17 ("Society will continue to solve even the biggest environmental problems"), from “I don't agree” (-4 dark) to “I agree” (-1 light), grouped by country by alphabetic order: CY = Cyprus, DE = Germany, EE = Estonia, FI = Finland, FR = France, HU = Hungary, IT = Italy, LT = Lithuania, MT = Malta, PL = Poland, PT = Portugal, RO = Romania.

* An other between analysis shows that biology teachers (InB and PreB) have more scientific knowledge on GMO than their colleagues, and are also more pro-GMO.

* An other between analysis shows a significant gender effect, men being a little more pro-GMO than their female colleagues.

* We also found a significant effect of the teachers' level of qualification: more a teacher studied in University more he or she disagrees with the proposition "Our planet has unlimited natural resources".

CONCLUSIONS

The controversial issue of GMO is only partly linked to other conceptions on Environment, and has some specificity. The differences among the countries are mainly related to teachers' values, their philosophy of Nature, utilization or preservation of Environment. The opposition between pro- and anti-GMO are found inside each country, with some significant correlations with the teachers' gender, their level of qualification, and the difference between the biology teachers and their colleagues. Finally, the teachers' opinions on GMO are less linked to their knowledge on the possible danger of GMO for environment than to a reject of too much biotechnology, as already suggested by de Chevigné (2004).

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FINDING A SUSTAINABLE CULTURAL IDENTITY AS A SCIENCE TEACHER EDUCATOR: A MOZAMBICAN PERSPECTIVE

Alberto Cupane
University Pedagogica Maputo
acupane@hotmail.com

Peter Charles Taylor
Curtin University of Technology
p.taylor@curtin.edu.au

ABSTRACT

Mozambican schools are not helping students to see themselves as culturally rich beings because local cultural values, traditions, knowledge and beliefs have never been included in the curriculum. More than 30 years after independence from 500 years of Portuguese colonial rule, Mozambican science teachers continue to serve as agents of assimilation of students into a Western modern worldview that is indifferent to their local cultural identities and aspirations. As a science teacher educator preparing new teachers for Mozambican schools Cupane (first author) saw his cultural identity to be part of the problem and part of the solution. He designed a critical auto-ethnographic inquiry and explored (and transformed) his cultural identity as he addressed the key research question: *How can school science serve better the cultural development of local school communities in Mozambique?* A key outcome of this research is Cupane's multi-cultural identity as a Mozambican, an indigenous (Changana) person, a world citizen, and a science teacher educator. Generating this understanding has fuelled his vision of future science education for Mozambique for which he has articulated a culture-sensitive philosophy of physics teacher education.

Keywords: *culture, identity, indigenity, non|essentialism, critical auto-ethnography*

INTRODUCTION

Indigenisation of the science curriculum has become a worldwide issue for Western nations with substantial indigenous populations such as Canada and South Africa. In Australia the new national primary science curriculum is currently being 'indigenised', but there is no shortage of debate about how best to accomplish this controversial task. On the one hand, mainstream scientists are questioning the academic status of indigenous knowledge. On the other hand, critical science educators are complaining about indigenous culture being assimilated into the dominant Western modern worldview. In Mozambique local cultural values, traditions, knowledge and beliefs have never been included in the curriculum. As a science teacher educator preparing new teachers for Mozambican schools in the postcolonial era Cupane (first author) saw his cultural identity to be part of the problem and part of the solution. He designed a critical auto-ethnographic inquiry, involving narrative and autobiographical research methods, socio-cultural theories and dialectical thinking, and explored his cultural identity as he addressed the key research question: *How can school science serve better the cultural development of local school communities in Mozambique?* (Cupane, 2007).

THEORETICAL PERSPECTIVE

Under Portuguese colonial rule school curricula in Mozambique were based on an 'essentialist' view of culture (Ashcroft, Griffiths, & Tiffin, 2000) in which indigeneity is non-existent in modern life because interaction with the West destroyed the purity of the Indigenous people (Semali & Kincheloe, 1999). From this perspective, indigenous knowledge is understood as primitive, and although it is has become a focus of academic knowledge it is not yet widely regarded as legitimate academic knowledge that can be studied in the science classroom. And so Mozambican science classes continue to serve as sites of uncritical assimilation, or one-way border crossing, into the Western modern worldview, thereby robbing Mozambican children of the opportunity to develop a more complex, dynamic and sustainable cultural identity. In this study, a 'non|essentialist' perspective on culture as a dynamic process was adopted, where '|' signifies a dialectical relationship between nonessentialism (cultural instability) and essentialism (cultural stability). In this view, identity is characterised by the way that family, religion, political agency, education and human rights have significance for the individual as self, connected to human aspirations in a given space. This is moral identity and is shaped by family, neighbourhood, the city and the ethnic group. Sfard and Prusak (2005) suggest that identities can be known by stories told by individuals. Identity results from everyday interactions and decisions taken in everyday life. This notion of identity can help to unravel how the processes of academic failure and success occur in school science, especially in a postcolonial context.

METHODOLOGY

For science education, critical auto-ethnography is an innovative research method that draws on multiple research paradigms to engage the researcher in a process of transformative professional development (Ellis & Bochner, 2000; Taylor, Settelmaier & Luitel, in press). In this study, the first author undertook prolonged critical reflexive inquiry into his cultural identity by: excavating his cultural memory using a range of logics (metaphor, dialectics, poetics), representing this experiential data via numerous genres (story, narrative, poetry), subjecting it to critical theoretical scrutiny (or decolonisation), and engaging in creative reconstruction via a process of philosophical envisioning. The second author served as his 'critical friend'. A range of rigorous quality standards (alternatives to validity, reliability, objectivity) were used to regulate the generation of the researcher's personal practical self-knowledge. They will be explained in the paper.

OUTCOMES

For me (Cupane), one of the major outcomes of this research was coming to know 'who I am', both as a Mozambican and as a professional science educator. An important realisation is how incomplete is the cultural identity given by my ID card. The physical environment, my cultural capital, the weather, and my students are all stimuli that elicit different aspects of me, but my ID card states that I am a science teacher educator without feelings. I have come to believe that my full professional identity can parade in the science classroom only when these stimuli are in a sustainable relationship. This transformed self-understanding helps me to be at peace with myself as: a Mozambican, an indigenous (Changana) person, a world citizen, and a science teacher educator. This understanding has fuelled my vision of future science education for Mozambique, given that we are living not only in a free market period but also within previous times and that this entanglement is dangerously invisible to us. Our school science curricula continue to serve only the modern Western worldview, ignoring the urgent realities of both the traditional and rapidly emerging 'post|modern' worldviews of contemporary Mozambican society. By making clear in my own professional practice how I have achieved my personal sustainability, a clear sense of who I am, my colleagues and students (pre-service physical science teachers) can benefit as they are facing similar problems of cultural identity and curriculum adaptation. The paper will explain this outcome in detail, especially my emergent philosophy of a culture-sensitive physics teacher education for Mozambique.

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THINKING ABOUT SCIENCE – THE IMPORTANCE OF INTUITIVE IDEAS FOR MEANINGFUL LEARNING

Arne Dittmer **Ulrich Gebhard** **Rosemarie Mielke** **Kerstin Oschatz**

Didactics of Biology & Educational Psychology, University of Hamburg, Germany

ABSTRACT

This paper describes the didactic concept and research program "Intuition & Reflection" (Gebhard 1994, Gebhard & Mielke 2001), its theoretical fundamentals as well as empirical data and the implications of this research for students, pre-service teacher trainees and science teachers. Within the theoretical approach presented here the relevance of reflecting the intuitive mind to promote critical thinking among biology students and pre-service teacher trainees is investigated. While dealing with topics like gene technology intuitive ideas concerning perspectives on mankind and the world get activated. Dual-process models of information processing, give an insight into the importance of internalized convictions and beliefs, for dealing with new information. Internalized ideas are highly important for the emergence of intuitive appraisals as well as the interest and the behaviour that individuals display while dealing with a topic. Reflecting on intuitive ideas linked to gene technology during learning of genetics was shown to have positive effects on learning within field studies. In an experimental study these effects have been further examined.

CULTURALLY ROOTED INTUITIVE IDEAS ABOUT MANKIND AND THE WORLD

There is a growing awareness that reflecting on the nature of science and ethical aspects of sciences should be an integral part of science education. The biosciences influence our daily lives and the visions of biomedicine, gene technology or socio-biology alter our perspectives on mankind and the world. They touch on central questions of how we want to life, what we can know or what it means to be human. Such topics automatically stimulate intuitive ideas about the holiness of live or the idea that natural things are intrinsically good. Such ideas are grounded in cultural knowledge and learned during socialisation mostly in an implicit way. One central concern of the didactic approach and research program "Intuition & Reflection" is the question, how science education can promote the development of scientifically literate citizens. Traditional educational approaches just focus on reflective thinking and ignore the importance of nonreflected implicit beliefs. Reflective thinking is just one way to process information about the world and is considered an expensive cognitive way of decision making.

DUAL-PROCESS MODELS AND THE SOCIAL INTUITIONIST MODEL OF MORAL JUDGEMENT

Dual-process models of information processing permit a better understanding of the meaning of internalized convictions for the evaluations, the interest and the behaviour that individuals display when dealing with a subject. According to these models information can be processed reflectively or automatically (Chaiken & Trope 1999). Consciously reflected behaviour requires heightened attention capacities and is therefore the exception rather than the rule in everyday life. Most information is processed uncontrolled through an automatic activation of ideas. How closely subject area matters and other associations are connected in a person’s memory, determines how fast they come to one's mind spontaneously. Dual-process models therefore allow for a more in depth understanding of the importance of internalized convictions for the emergence of intuitive appraisals of a matter as well as the interests and behaviour that ensue (Strack & Deutsch 2004). From a psychological perspective the brain is a connectionist system that tunes up slowly, but is then able to evaluate complex situations quickly. According to this psychological explanation of the role of intuitive thinking, Haidt (2001) postulates his *Social Intuitionist Approach* to moral judgment. In this model it is claimed that evaluating intuitions come first and directly cause moral judgments. The social part of the Social Intuitionist model proposes that judgments are influenced by cultural rooted values and social interactions. According to this model reasoning may occur objectively just under very limited circumstances: when the person has enough time and processing capacity and the motivation to be accurate. The Social Intuitionist approach is also relevant in respect to the hidden ideas about science and nature. As implicit knowledge these ideas influence our thinking about the ethical aspects of biosciences.

EMPIRICAL DATA

Reflecting on intuitive ideas linked to gene technology during the learning of genetics, had positive effects on learning, within field studies. Within an interventional study, it was shown that the integration of student’s intuitive ideas on genetic engineering into their learning of the subject had a positive effect on their learning efficiency (Born 2008). Students of the interventional classes showed substantial progress in learning compared to students of control classes, especially in the follow up. In an experimental study these effects were further examined in respect to the underlying cognitive processes. Results reveal an immediate irritational effect of the reflection of intuitive ideas that indicates the importance of these automatically generated ideas. Participants of the treatment group scored lower on subsequent achievement tests than did control group participants. Especially learners with a high *need for cognition* (Cacioppo & Petty 1982) and sophisticated epistemic beliefs (Hofer 2001) were affected, using more cognitive capacity to process their intuitive ideas reflectively (Oschatz et al. 2009). Results of a second experimental study show the importance of social interactions for the fruitful reflection of intuitive ideas. After discussing their intuitive ideas with others, participants of the treatment group with a high *need for cognition* and sophisticated epistemic beliefs scored higher on subsequent achievement tests than participants of the control group with high *need for cognition* and sophisticated epistemic beliefs. Obviously the immediate effect of irritation turns into a beneficial cognitive stimulation, if learners are allowed to exchange their ideas with others and have more time to process their intuitive ideas. Social settings and social interactions matter because they encourage the development of reasoning. The Social Intuitionist model proposes an arrangement that fully integrates reasoning, emotion, intuition, and social influence.

PHILOSOPHIZING IN SCIENCE CLASSES AND THE OPEN-MINDED TEACHER

The relevance of this didactic approach and research programme can be discussed in three ways: First there is a need for open minded science teachers, who are informed about the cultural roots of beliefs and values. During their science studies pre-service teacher trainees have to think about their profession in a broader and deeper manner. Second there is a need for learning styles in science classes which promote critical thinking and philosophizing about the relation between science and culture. Philosophical enquiry is an activity to reconstruct intuitive ideas about science. The method “Philosophy for Children“ (Lipman 1991) for example is an activity of philosophical questioning and concept-analyses connected with an attitude of open-mindedness and dialogue oriented communication. These techniques and attitudes seem to be necessary conditions for becoming a scientific literate educator and citizen. The structure of many science lectures however does not have a form that requires a deeper understanding of science or to reflect internalised beliefs and values (Dittmer 2010). Third there is a need to develop a detailed understanding of the interactions between reflective and intuitive thinking in science education.

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TEACHING THE GENETICS OF COMPLEX TRAITS

Michael J. Dougherty

Director of Education
The American Society of Human Genetics
9650 Rockville Pike
Bethesda, MD 20814 USA

mdougherty@ashg.org

ABSTRACT

The goals of primary and secondary science education are to help prepare scientifically literate citizens and future scientists. Scientific literacy is perhaps most personally meaningful and necessary in genetics and medicine. Rapid changes in human genetics, in particular recent insights into the genetics of complex traits, may revolutionize healthcare. However, citizens are ill-prepared for this transformation. One potential solution is to modernize the genetics curriculum so that it matches the science of the 21st-century. This paper outlines the problems with current genetics instruction, highlights changes in human genetics that support a curricular reorganization, and proposes a new genetics curriculum.

Keywords: *Genetics; complex traits; scientific literacy; curriculum; medicine*

INTRODUCTION

In spite of efforts to improve science education, students in the United States continue to lag behind their peers in other countries (PISA 2006). This underperformance is true for genetics, and for science and math in general, and is particularly worrisome given the accelerating need for scientists and engineers in an increasingly technology-driven economy (Table 1, O'Sullivan, 2003). Unfortunately, even students in high-performing European countries, such as Finland and Slovenia, have relatively small percentages of students performing at the higher levels of proficiency (PISA, 2006).

TABLE 1

NAEP test results in 2000 for science reveal a deficit in student understanding of core genetics concepts (O'Sullivan *et al*. 2003)

Theme	Grade	Students with complete/essential answers (%)	Students with partial answer (%)	Students with unsatisfactory answer (%)
Classification	8	23	16	58
Theory of evolution	8	53	NA	45
Reproduction	12	61	NA	39
Evolutionary relationships	12	25	NA	70
Darwin's theory of evolution	12	51	NA	47
Genes*	12	21	45	30
Mutation*	12	2	33	58
Interpreting genetic material*	12	1	1	83
Genetic disease*	12	5	31	56
Recombinant DNA usage*	12	8	27	58

Percentages may not total to 100 due to rounding and student omission (i.e., no answer was given).
*These questions are in the molecular and human genetics category.

METHODS

A comprehensive review of the genetics education, curriculum, and genomics literature was conducted to ascertain the status of current genetics instruction. Those results led to new hypotheses regarding how genetics concepts should be taught. Current work to develop new curricula to test those hypotheses is in progress as is research to determine the possible impact of U.S. education policy on genetics instruction.

RESULTS

The field of genetics research has changed rapidly as a result of the dramatically reduced costs of DNA sequencing. Researchers can now examine a person's entire genome for genetic contributions not only to single-gene, Mendelian disorders but to complex traits related to health and disease, such as height, weight, diabetes, and autism. Complex (or quantitative) traits are the result of many genes working together and with the environment. Understanding complex trait genetics is now critical for the preparation of the next generation of geneticists and health-care consumers.

Unfortunately, only 10-15% of state science standards in the U.S. specify that students should learn about complex trait genetics, which means that those concepts are rarely taught in middle and high school biology classes. Instead, genetics instruction remains focused almost exclusively on simple, single-gene traits. Undergraduate genetics also emphasizes simple inheritance at the expense of complexity (Hott, et al, 2002; Dougherty, 2009). Moreover, the sequence of topics taught in most genetics courses roughly follows the historical development of genetics research, which until recently focused (necessarily) on Mendelian inheritance of dominant and recessive traits. This outmoded sequence continues to be used in spite of evidence that it is ineffective and leads to a variety of common misconceptions about genetics (Shaw, et al, 2008).

CONCLUSIONS

These findings are problematic. With large increases in the number of genetic tests available, including direct-to-consumer genetic testing, our students need to understand how concepts such as inheritance and risk differ between complex and simple traits. Genetics also raises ethical, legal, and social issues that students and the public should understand. Geneticists have always been interested in complex traits, but the emphasis on single-gene traits was a natural consequence of the fact that those were the phenomena we could best apprehend, a situation that is still true. However, given what we know about the deficiencies in the current curriculum and student understanding, and armed with an improved understanding of the genetics of complex traits, there is no longer a compelling reason to maintain the historical sequence of our syllabus. Indeed, the direction of genetics research and medicine suggests that an alternative may be in order. Specifically, it may be preferable to “invert” the curriculum—that is, introduce common complex traits before rare, single-gene traits—to close the gap in student understanding (Dougherty, 2009).

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ENVIRONMENTAL LITERACY of PRE-SERVICE SCIENCE AND MATHEMATICS TEACHERS IN TURKEY: EFFECT of GENDER AND ACADEMIC MAJOR

Betul Ekiz	Elif Selcan Kutucu	Huseyin Akkus
Yuzuncu Yil University	Yuzuncu Yil University	Gazi University
ebetul@metu.edu.tr	kselcan@metu.edu.tr	akkus@gazi.edu.tr

ABSTRACT

The purpose of this study is to investigate the relationship between gender and academic major of pre-service science and mathematics teachers and their environmental literacy. Environmental literacy questionnaire was used to collect data. The result of the study revealed that although there is no statistically significant difference between female and male pre-service teachers environmental literacy, mean scores of female pre-service teachers is greater than males in terms of their environmental attitude, concern and behavior. A significant difference was found among academic majors of pre-service teachers. Also environmental concern of pre-service teachers was correlated with their parents' interest to environmental problems.

Keywords: *Environmental literacy, pre-service teachers, gender, academic major*

INTRODUCTION

Great importance should be given to the environmental literacy in environmental education due to the increase in environmental problems. Environmental literacy includes four major components (Disinger&Roth, 1992) namely knowledge, attitude, concern and behavior and it is important to know pre-service teachers opinions of these constructs as environmental literacy influences teaching activities of a teacher in environmental education. Academic major and gender are crucial variables in investigating environmental literacy of individuals (Ozturk, 2009). Because of this, the primary purpose of this study is to investigate the effect of gender and academic majors of pre-service science and mathematics teachers on their environmental literacy. The secondary purpose is to investigate if there is a correlation between components of environmental literacy and parents' concern to the environmental problems.

METHOD

In this study, the survey data was statistically analyzed by using multivariate analysis of variance (MANOVA). The independent variables were academic major and gender of students. Environmental literacy questionnaire which is composed of four dimensions such as environmental knowledge, environmental attitudes, perception of environmental uses and environmental concerns were the dependent variables of our study. All analyses were conducted at the 0.05 level of significance. The knowledge component of questionnaire is composed of multiple choice items to assess pre-service teachers' knowledge about current environmental issues and it was developed by National Environmental Educational and

Training Foundation (NEEFT) and Roper. The other three components are regarding pre-service teachers' environmental attitudes, uses and concerns using five Likert-type scales. The instrument was originally developed in English and, translated and adapted into Turkish. The internal consistency of the knowledge, attitudes, uses, and concerns dimensions were found to be 0.88, 0.64, 0.80, 0.88, using Cronbach alpha respectively (Tuncer et al., 2009). In our study, the internal consistency of the knowledge, attitudes, uses, and concern components were found to be .44, .43, .70, .72. using Cronbach alpha respectively. This study was conducted with 167 pre-service teachers (124 female, 43 male) from chemistry (48 individuals), physics (48 individuals), biology (37 individuals) and mathematics (34 individuals) majors in secondary science and mathematics education department in a public university in Turkey during fall semester of 2009.

RESULTS AND CONCLUSION

The mean responses of environmental literacy components were compared by gender and academic majors of students. Firstly, the result of analysis testing gender differences indicated that female pre-service teachers have greater mean than their male counterparts in terms of all environmental literacy components except for environmental knowledge (see Table 1). This result is consistent with the previous research results (Tuncer et al., 2009). However, no statistically significant difference was found between female and male pre-service teachers in terms of environmental components.

Table1. Mean environmental literacy components by gender

	Males		Females	
	M	S.D	M	S.D
Knowledge	7.14	1.97	6.55	1.86
Attitude	3.43	0.65	3.50	0.37
Use	4.14	0.40	4.23	0.32
Concern	3.84	0.68	3.92	0.73

Secondly, the role of academic major on environmental literacy of pre-service teachers was investigated and the result indicated that there is a significant difference among pre-service teachers from different academic majors as consistent with other studies (Ozturk, 2009; Goldman, Yavetz & Pe'er, 2006). The analysis of environmental literacy components' means showed a significant difference in the mean score of pre-service teachers in terms of environmental attitude ($F= 3.984$, $p< .05$) items.(see Table 2)

Table2. Comparison of mean environmental literacy components with respect to academic majors

Major	F	p	η^2
Knowledge	1.037	0.378	0.019
Attitude	3.984	0.009	0.070
Use	1.038	0.378	0.019
Concern	1.494	0.218	0.027

Finally, the result of this study revealed that there is a medium positive correlation between the parents' concern about environmental problems and environmental concern of pre-service teachers (r =.281). However, no significant correlation was found between environmental concern of pre-service teachers' parents and their responses to the environmental behavior and knowledge components.

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WHAT HINDER SCIENCE TEACHERS IN SECONDARY SCHOOL FROM CHANGING THEIR TEACHING PRACTICE IN WANTED DIRECTION?

Ingebjørg Ellingsen

Nesna University College

ingebjrge@yahoo.no

Atle Ivar Olsen

Nesna University College

ao@hinesna.no

Wenche Sørmo

Nesna University College

ws@hinesna.no

ABSTRACT

Many Norwegian science teachers want to make changes in their teaching practice. They want the pupils to be more active, talk more about scientific topics and do more scientific activities. However, it seems to be difficult for the teachers to change their teaching practice in that direction. Some explanations of why they want more practical teaching given by science teachers in secondary school, seem to be increasing pupils interest, having dialogues around science and to learn practical science. The same teachers say that the factors that hinder them from making desired changes are size of classes, the teachers' competence and time.

Keywords: science education, secondary school, pupils-active, curriculum, interview

INTRODUCTION

A survey from 2008 by Olsen et al. (2010) is the background for this investigation. Their results showed that teachers who had specialized in science use practical work for the pupils in their science lessons, more than average in Norway (Martin et al., 2007). Still, many of them wanted to make the lessons even more practical, and the pupils more involved and active (Sørmo et al., 2010), Inquiry–based learning (Spronken-Smith et al., 2007) and other methods in the term of constructivism (Quale, 2007) seemed to be the motive mainspring for the teachers.

What reasons can be found to explain the teachers wish for more activity, and what hinders them from doing that? This investigation focuses on teachers in secondary school and to elaborate their opinions about what limit their science teaching.

METHOD

A questionnaire (52 questions) about science teaching, limitations, classes, teaching methods, the curriculum, the school, and questions about whether the teachers want to change anything, was sent to 35 secondary school science teachers on 16 different schools in Troms County in Norway. We got answerers from 25 teachers from 12 of the schools. The answers were used to select four informants that wanted to change their teaching practice in their science lessons to an even more activity based way of teaching. The informants were interviewed (semi structured) about their teaching methods, their practical work in science lessons, and what limited their science teaching and their work priority in the lessons, to try to identify what factors hinder them from changing their teaching the way they actually want to.

RESULTS AND DISCUSSION

The whish to change teaching methods

The teachers wanted to change their classroom teaching in many ways (Table 1, results from questionnaire). The teachers answered that what they wanted most to do more was "Visits to museums, industry etc.", but also as many as 75 % wanted to do more "Field work and excursions". Also "Working in Groups" (58 %) and "Pupils do experiments" (50 %) scored high.

The results from the interviews of the 4 informants in our investigation seem to correspond with that point of view. They said that they wanted to do more thorough activities, more practical science and more dialogue around the activities. This seems also to be in correspondence with litterature, as an investigation on Norwegian pupils in 7^{th} grade indicated that pupils preferred teaching with activities (Tveita et al., 2003). The same investigation showed that the pupils' attitude to science was better in classes where the teaching was based on activities. TALIS (Vibe et al., 2009) reported that Norwegian teachers find it important that the pupils can think and try out hypothesis themselves and that the pupils thinking and reasoning is more important than the right answers.

Table 1. Science teachers wish to change their working methods (to have more of some activities) in the classroom. Answers from 24 teachers on questionnaire.

Working methods in science teaching	No change	More often
Pupils do experiments	12	12
Working in groups	10	14
The budding researcher	17	7
Field work and excursions	6	18
Drama and role play	20	4
Discuss science from media	17	7
Outdoor teaching	15	9
Using computers	20	4
Using internet	19	5
The pupils participate in planning the lessons	13	11
Visit to museums, industry etc.	3	21

Limitations for a more active science teaching

There seems to be many factors that limit the science teaching (Table 2, from questionnaire). Most problematic seems to be transported to excursion areas" where as many as 16 teachers (65 %) state that this hinders their science teaching and this also correspond and explains the results presented in Table 1 about what they wanted to do more.

Table 2. Hinders for science teaching for teachers in secondary school. Replies from 25 teachers.

Limiting factor:	not at all	small grade	some grade	much
An own teaching room for science	12	2	2	9
Equipments at school	2	5	14	4
Economy at school	1	10	9	5
Transport to excursion areas	3	6	7	9
Teamwork among science teachers	6	9	7	3
Pupils interest	6	10	6	3
Number of pupils in science class	5	8	8	4

When interviewed about the same, two informants said that practical science teaching required a lot of preparation, and thus available time seems to be one of the most limiting factors. They thought it was very individual how much time science teachers would spend on this work. Two informants mention the size of the science classes and the economy as a limitation. Three informants are telling about lack of modern equipment.

CONCLUSIONS

The science teachers interviewed already have activity based teaching in science but they state that this is important and they all want to have even more activities. The reasons that they cannot obtain this are above all lack of time for preparations, but also economy, the teachers own competence and number of pupils in science class limits them.

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THE TROUBLE OF CULTURAL VALUES IN SCIENCE EDUCATION: TOWARDS THE CONSTRUCTION OF THE "EUROPEAN MODEL OF SCIENCE IN SOCIETY"

Alexandro Escudero Nahón

Universitat de Barcelona

aescudna7@alumnes.ub.edu

Diana Farías Camero

Universidad Nacional de Colombia

dmfariasc@unal.edu.co

ABSTRACT

There is a widespread agreement within the scientific community about the main factors which hinder new scientific vocation from coming out: the lack of interest and negative attitudes toward science and technology amongst the youth; moreover, they are the obstacles that stand in the way of restructuring the relationship between science and society. This work identifies what kind of difficulties arises by the category *culture* when interpreting the attitudes and opinions of the youth through science and technology. We describe the context where science is democratized, compelling the scientific and technological system to keep a constant dialogue with the emerging political powers of society, and finally we explain what the advantages are of including a concept of identity when making a critical reflection of the challenges that the construction of the "European model of science in society" must overcome.

Keywords: *culture, science, technology and society (STS), identity, science education.*

INTRODUCTION

There is a widespread agreement within the scientific community with respect to the lack of interest and negative attitudes toward science and technology amongst the youth, that they are the main factors that hinder new scientific vocations from coming out and they will be the obstacles that will shape the scientists who initiate the "European model of science in society," scientists whose objective is to create a new *scientific citizenship* in society using the process of *scientific democratization* as the medium (MASIS Expert Group, 2009).

The significance that diverse groups have given to the problem that the image of science is being belittled in the eyes of the youth (for example, OECD, 2000) has led to studies being carried out, which identify the causes of this situation and suggest actions of intervention; has led to the interpretation of results of international studies that surveyed the opinion of the youth with respect to science, results which have given rise to models that attempt to restructure the relationship between science and society.

RESULTS

This is not empirical research, but a theoretical reflection about the relationship that connects three issues: *culture* as analytical category, the identity as a subjective dimension, and science and technology as social issues. In this reflection, we used some results from the Rose Project. These revealed that the more developed a country was, the smaller the interest its youth had in science and technology. The project also revealed that gender determined the views, values, interests and attitudes toward science (Sjøberg and Schreiner, 2008). These kinds of results have been interpreted, like others, from the perspective of *cultural differences*. However, the category *culture* cannot explain, for example, why boys from developed countries, like the other boys and girls from developing countries, think that science and technology can solve all of the environmental problems, and that the solution is to be left to the experts; while the girls of those same developed countries, along with Japanese boys and girls, appear to be more skeptical and critical in the face of the role of science. In these cases, the category *culture* is not able to interpret these incoherencies.

Regarding the models that suggest restructuring a new relationship between science and society, the recent publication *Challenging Futures of Science in Society: Emerging Trends and Cutting-edge Issues* puts special value on the categories *culture*, *multiculture* and *pluriculture* as ground conditions for democratic participation (MASIS Expert Group, 2009).

The problem that arises when using the concept of culture to interpret the results of international studies that survey opinion and in the design of models that attempt to reconfigure the relationship between science and society, is the same problem that the social sciences face when trying to reformulate the concept of cosmopolitan citizenship. Studies done in philosophy, politics, and sociology have revealed that the concept of culture, conceived during the 18th century with the impetus of european colonialism, brings out more problems than answers when it defines the role of the postmodern subject of post-industrial and global societies. Introducing concepts of *culture*, *multiculturalism*, *interculturalism* or *pluriculturalism* when describing present societies we make the mistake of understanding culture only as homogeneous, unified, holistic and self-coherent groups, as whole groups that have no interior conflict, where the strength of tradition submits particular identities (Benhabib, Honig, Kymlicka, Post and Waldron, 2008; Nussbaum and Glover, 1995).

CONCLUSIONS

In this work we have identified the main problem we face when the category *culture* is used in order to interpret the attitudes and opinions of the youth about science and technology. Nowadays the category *culture* does not allow us to explain social phenomena in contemporary societies where its people do not base their identity using conventional references such as nationality, language, gender or race.

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EXAMINING A SCHOOL-BASED ECOLOGICAL CITIZEN SCIENCE PROGRAM

Xavier Fazio

Brock University
Faculty of Education
Department of Teacher Education

xavier.fazio@brocku.ca

Douglas Karrow

Brock University
Faculty of Education
Department of Teacher Education

doug.karrow@brocku.ca

ABSTRACT

We present an analysis of an ecological citizen science monitoring program called "NatureWatch". In our study we explored the successes and challenges of an ongoing collaborative partnership involving elementary and secondary schools, faculty of education, and a federal government agency. Using Wenger's theory of *communities of practice* (CoP) we analyzed this program and discovered that it aligned well with this theory. Importantly, using Wenger's principles helped explain the successes and challenges that were exhibited throughout the duration of the partnership. Based on our findings, implications for the development of ecological citizen science monitoring programs in schools are presented.

Keywords: *citizen science, schools, communities of practice, ecological monitoring.*

INTRODUCTION

In this presentation we provide an analysis of an ecological monitoring partnership amongst elementary and secondary schools, faculty of education, and a federal government agency. Specifically, we report how the Ecological Monitoring and Assessment Network (Environment Canada, 2008) citizen science program called "NatureWatch" was adapted by schools, and explore the successes and challenges of this collaborative partnership.

NatureWatch is a suite of ecological monitoring and assessment programs, which include: *FrogWatch, PlantWatch, WormWatch,* and *IceWatch*. The Ecological Monitoring and Assessment Network (EMAN) is made up of organizations and individuals across Canada involved in ecological monitoring to better detect and report on ecosystem change. To support environmental education curriculum goals, in 2006, a collaborative partnership was established with an elementary school aligning with EMAN ecological monitoring activities. This partnership is ongoing and has been extended to include an additional elementary and secondary school. Our research focused on how this partnership: (a) influences the efficacy of implementing these programs within elementary and secondary schools; and, (b) nurtures the development of ecological literacy with students and teachers.

METHODS

This research design is a qualitative case study (Creswell, 2003; Stake, 2000) of 'NatureWatch' implementation within two elementary and one secondary school This approach involves empirical investigation of particular phenomena within an authentic context. For the purposes of this research, a case study methodology is appropriate because of our research questions, design considerations, and pragmatic concerns. Research data consists of: (a) pre and post semi-structured interviews of key participants' views of in-service and implementation and, (b) researcher's narrative accounts as marginal participants during inservice, and implementation of the protocols at the school sites. Semi-structured interviews solicited basic participant information, familiarity with protocols, and understandings around citizen science, and ecological literacy prior to and after implementation in the school community. Direct observations, via narrative accounts of teacher inservice and implementation, complemented data obtained from interviews. Specifically, the researchers acted as marginal participants during these activities, and as 'participants-as-observers' during EMAN protocol activities.

RESULTS

Our findings are based on our analyses of interviews, field observations, professional development sessions, and various documents amongst three school cases. The evidentiary data presented in the findings were organized around patterns of data found across all three school cases.

In general, our results indicated that *NatureWatch* is a viable model for implementing a citizen science ecological monitoring program within schools. However, in order to fully realize the full potential of this program within schools, a deeper understanding is required by all participants regarding the purpose of community-based monitoring, the presence of necessary human and material resources to effectively implement ecological monitoring protocols, and a fundamental understanding and framework for creating and sustaining partnerships.

Using Wenger's (1998) notion of CoP we were able to analyze this school-university-government partnership from a systems perspective. This partnership aligns well with Wenger's characteristics and suggests that the development exhibited in this partnership can be attributed to the creation of a CoP. Accordingly, three basic characteristics were used to describe the partnership as a community: engagement, alignment, and imagination. More importantly, using Wenger's concepts helped explain the interactions between novices and experts participating in the partnership, and provided explanations for the successes and challenges that were exhibited throughout the duration of the partnership.

CONCLUSIONS

Our findings suggest that 'NatureWatch' is a viable model for implementing a citizen science ecological monitoring program with schools and, as such, supports EMAN's program objectives. Biodiversity data had never been collected by EMAN from various schools' geographic areas. This increase in geographical coverage of monitoring information is a specific goal of the program, thus allowing better detection of ecosystem change in the schools' regions. Clear engagement and alignment with the program's domain was demonstrated by all participants.

Partnerships between government agencies and schools are inherently challenging. Hence, considerable efforts are required to forge relationships because of the contrasting structures and frameworks of the respective institutions. "Building bridges" between diverse institutions requires skilled facilitation necessary to promote trust and cooperation

This partnership aligns well with Wenger's characteristics and suggests that the development exhibited in this partnership can be attributed to the creation of a CoP. More importantly, using Wenger's concepts helped explain the interactions between novices and experts participating in the partnership, and provided explanations for the successes and challenges that were exhibited throughout the life of the partnership. While successful, our community project had challenges, including sustainability of the partnership over time. Other challenges included: cultivating a community, developing effective knowledge structures that evolve with the project, and leadership for the various subgroups. These are critical areas that require further research and development for promoting environmental education in school contexts, and supporting sustainability efforts in communities.

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PROMOTING PUPILS' INTEREST IN SCIENCE – SOME NEW APPROACHES IN POLAND

Anna Florek

Department of Chemistry
University of Gdansk, Poland

e-mail: aniahebe@gmail.com

Rajmund Kaźmierkiewicz

Intercollegiate Faculty of Biotechnology
UG-MUG, Poland

e-mail: rajmund@biotech.ug.gda.pl

ABSTRACT

The purpose of this work is to propose a range of methodologies for the inclusion of modern research methods used in science (e.g. molecular modelling, electrophoresis, mass spectrometry,) within the school curricula and practice in Poland at upper secondary level. The main educational goal is to develop a student's interest and inspire their curiosity for the study of chemistry and science at school level. The inclusion of teaching material about modern techniques and their uses in disciplines such as medicine and the technology involved in the production of everyday materials can develop student motivation and hence provide a more effective science education. The main focus is for students of non science specialists classes. Emphasis is given to the implementation of modern knowledge into present day curricula and to find a way for a methodological connection between obligatory and modern topics. All projects have been tested with groups of students during preliminary school lesson and laboratory activities. The potential of the projects in school practice and their effectiveness are evaluated using a range of techniques.

Keywords: *new topics, methodological projects, educational tools, students' interest of science*

In chemistry and science education it is important to offer the postsecondary school students information about the development of chemistry and other science disciplines and that students will be able to make a more informed choice for their future career. A further key aspect is to show our students how modern, useful and interesting chemistry is in our time (Nelson, 2005).

The main educational goal is to encourage a form of teaching which would enable students to understand some issues about improving and implementing modern technologies in science. In the projects an important goal is to find the most interesting application of modern research techniques concerned with the connection of applications of these two issues of students needs and interests (such as health, diet, beauty, everyday equipment, problems discussed in the mass media). It is necessary to find the best solutions, both educationally and structurally, for teaching interdisciplinary problems during traditional chemistry curses (Florek, 2007).

To prepare these educational projects it was necessary to search resources of science news, analyses the content of current school curricula, choose new topics and prepare different kinds of methodological projects together with any didactic tools for students and teachers. The main subject of that work was modern research technologies used in science (e.g. molecular modelling, mass spectrometry, electrophoresis etc.). For example the computer research method -molecular modelling- is one of the fastest growing fields in science. It may vary from building and visualizing molecules to performing complex calculations on molecular systems (Ercolessi, 1997; Wales 1999). Using molecular modeling scientists will be better able to design new and more potent drugs and a vast array of new materials (protein engineering). Electrophoresis (with polymerase chain reaction PCR) is the analytical chemistry development for research of DNA and the genetic code (Matthews, 1997).

I am designing a range of new methodological projects for school lessons (at the post-gymnasium level) which can bring these new topics together with traditional topics. The projects have been designed to be easy to use in school classes. The project has been tested by groups of students from Gdansk's schools during preliminary school lesson and laboratory activities during the last year. The effectiveness of the project was evaluated using a range of techniques. The results provide the data for the evaluation and the improvement of the projects. Mostly the preliminary results show an increase of students' motivation and interest in science. In addition, the results show the importance of offering the postsecondary school students information about the development of chemistry and other science disciplines and that these students are much better placed to make informed choices about their future career. The other aspect is to show our students how modern, useful and interesting chemistry is in modern times.

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STUDY ON INNOVATION AS STRATEGY FOR SCIENCE TEACHERS' CONTINUING EDUCATION

Paulo Sérgio GARCIA

Universidade de São Paulo, Faculdade de Educação, SP, Brasil.

garciaps@usp.br

ABSTRACT

In Brazil is common to use pedagogical innovations to legitimize traditional projects. This study examined the effects of an innovation project on science teachers' continuing education. We interviewed 11 teachers from three elementary schools. We collected data utilizing four categories: "situating the innovation", "implementation obstacles", "innovation type", and "innovation origin". The data showed that the use of pedagogical innovation as a strategy for teachers' continuing education reduces the learning process. The lack of support, time, and continuity are some of the obstacles. The findings presented here bode well for future analysis on the use of innovation on science teachers' continuing education.

Key words: *Innovation. Change. Science teachers' continuing education.*

INTRODUCTION

In Brazil, annually, schools receive many innovations with a variety of objectives, among them, those related to science teachers' continuing education. Nevertheless, the innovations have not been exploited in systematic studies like in other contexts.

In the European context, for example, the research of Huberman (1973) contributed to better understand the role of people involved in the innovative processes. Gonzáles y Escudero (1987) discussed the process of innovation development, focusing on the innovation' concept; Hernandez *et al*, (2000), Cardoso (2003), Correia (1989), and Carbonell (2002) are other authors that contributed with ideas and thoughts.

In the American context, the studies of Fullan (1992, 1993 and 2001) were determined to the understanding of innovation and educational change. In Brazil, we highlighted the work of Garcia (1980), and Krasilchik (1980) and (2000).

It is common in Brazil to use innovation project to solve educational problems. The term is used to legitimize old fashioned projects, and to standardize practices, not considering the diversity of social cultural context. The term is also used to describe improvements in quality of teaching, and as a strategy for science teachers' continuing education. Nevertheless, the innovation keeps a distance from simplistic thought, does not have a unidirectional meaning, and characterize itself much more as a process than a product.

Generally, the implementation of innovation is accompanied by some obstacles (Fullan & Hargreaves, 2000), and marked by the complexity, and by the impossibility of controlling its effects (Fullan, 2001 e Carbonell, 2002). In this way, the relationship between innovation and science teachers' continuing education is not so simple and straightforward, and many studies have already indicated the need of overtaking this utilitarian model and focus on institutional and professional development (Moreira, 1999). Nevertheless, it is common, in our country, the use of innovation as an end in itself, or as a strategy to solve educational problems. This study aim at investigating the effects of an innovation project on science teachers' continuing education.

METHODOLOGY

The overarching research question being addressed is: which are the effects of an innovation project on the science teachers' continuing education? To address this question in 2004 and 2007 the interview technique, with a previously defined script, was used with 11 teachers from three public schools in São Caetano do Sul, Brazil, who participated in the project from 2002 to 2006.

The data were collected utilizing four categories: 1) "situating the innovation", 2) "obstacles that impede the implementation of the project", 3) "type of innovation", and 4) "origin of innovation". In our questionnaire, the category "situating the innovation" analyzed how the teachers situated (understand) the innovation in relation to their continuing education; the category "obstacles that impede the implementation of the project" described the obstacles noticed by the teachers that hinder the implementation process. The category "type of innovation" showed which innovation' dimension was used, comparing to those proposed by Fullan (2001). The last category "origin of innovation" investigated the origin of the project and the implications to science teachers' education. We also analyzed all the innovation documents.

This project of innovation was promoted as a partnership between the São Caetano' Department of Education and the University of Sao Paulo. Innovation, which began in 2002, brought two major objectives: 1) the purpose of developing an innovative science education by combining science and telecommunications, integrating materials, laboratory experiments and demonstrations, and the exchange of information among schools in Brazil, and 2) the purpose of changing the science teachers' practice.

RESULTS AND DISCUSSION

Data analysis made possible to better understand about the use of innovation on science teachers' continuing education.

Teachers understood (situated) the innovation under a multiplicity of concepts, mainly, linked to changing, new and learning. Nevertheless, although teachers said that learning was one of the important outcomes of the project, they also said that other factors ended up attenuating this effect of innovation: the lack of time to discuss the implementation of the project; the difference between school and project' objectives; the lack of continuity, are among other factors that reduce learning process.

As to the obstacles that impede the implementation of the project, we could classify it in three kinds of factors: personal (lack of interest, anxiety, lack of confidence), professional (lack of support, lack of time, overload of working, lack of leadership), and contextual (lack of financial support, lack of resources). Some of these factors were already described in the literature: the overload of working (Fullan & Hargreaves, 2000); the organization and the functioning of school (Thurler, 2001), lack of time, support and the size of changing (Fullan, 2001).

With respect to the type of innovation, we found in the project documents the three dimensions proposed by Fullan (2001): 1) the introduction of new material such as curriculum or technologies; 2) the use of new teaching approaches, and 3) the modification of teachers' beliefs. Nevertheless, teachers identified only the first dimension. It means that the innovation did not affect teachers' beliefs, for example. Fullan used to say that to have good results we need to combine all three dimensions.

The results of this study showed that, even after five years of participating on the innovation project, teachers did not change their practice, and they were not using science and telecommunications in their normal classes. In this project, specifically, the results were small in comparison with the resources and time spent.

The data also indicated that we have to have some caution to assume innovation as a strategy on science teachers' continuing education. In fact, some studies have already suggested the need of overcoming this instrumental model, and recommend focusing on new strategies for institutional development (Moreira, 1999).

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THE QUALITATIVE COMPUTER MODELLING USING ModeLab²: AN EXPLORATORY STUDY WITH NOVICE UNIVERSITY STUDENTS DEVELOPING EXPRESIVE MODELLING ACTIVITIES OF TOPICS IN SCIENCE

Thiéberson Gomes

Federal University of Espírito Santo - Brazil

thieberson.ufes@gmail.com

Laércio Ferracioli

Federal University of Espírito Santo - Brazil

laercio.ufes@gmail.com

Rodrigo Marques da Silva

PUC - RJ – Brazil

Kathia Mariane Fehsenfeld

Federal University of Espírito Santo - Brazil

ABSTRACT

This paper reports results of a study about the Qualitative Computer Modelling using the Qualitative Computer Modelling Environment ModeLab². The study was developed based on an Extension Course offered to Physics novice university students at Federal University of Espírito Santo, Brazil. The study aimed at investigating also the efficiency of the collect data tools integrated in the Environment ModeLab². Results show that students were able to build models based on a short guideline text about the proposed system and to implement it in the ModeLab², and analyze them through the visualization of the graphical behavior generated by the simulation and, finally, validate or refuse them based on the observed behavior. The data collection tools allowed a considerable optimization of time to data collection for both the way data is generated and the easy access to data of the Model Building Process. These results lend support for the ongoing investigation about the integration of the ModeLab² in Science Education tasks with larger samples.

Keywords: *models, modeling, qualitative modelling, computer modelling environment.*

INTRODUCTION

The study of integrating information and communication technologies in Science and Technology Education has been the focus of a number of research programs around the world. Within this context, a number of contributions can be found related to the development of either computer modelling environment or modelling activities for applying them to the educational context (e.g. Ogborn, 1994; Gomes, 2008; Ferracioli, 2004; Gomes & Ferracioli, 2006). A ***Qualitative*** Computer Modelling Environment named *ModeLab²* (Ferracioli, 2004; Gomes, 2008), acronym of **Model**ling **Lab**oratory **2**D, was developed for integrating concepts of models and modelling in science classes through expressive activities and investigating cognitive modelling based on this kind of activity aiming at searching for modes of reasoning. Besides, the ModeLab² was developed with tools for collecting data and following-up activities to help the data analysis of the whole data generated by the investigation. This paper presents results of an investigation about this environment with expressive modelling activities developed by novice university students of Physical Sciences. The ModeLab² is available at http://modelab2.modelab.org.

THEORETICAL FRAMEWORK

Within the scientific context to study the world around us scientists choose specifics systems, phenomena or events to build models aiming at being able to explain and understand them. In this sense, *Models* are helpful to study structures that cannot be reached easily. A *Model* is a structural analogous of the world that has only some pieces of the reality and *Modelling* consists in to choose specifics pieces of the object, system or phenomenon of interest according to the focus of the study and build *Models* about them. Concepts like *Models* and *Modelling* can improve the learning process in the Educational Context and a way to introduce these concepts into it can be done using *expressive modelling activities*: students are requested to build models based on their own ideas about a proposed system. One of the ways how models are built on a Modelling Environment is concerned only with the objects of the system and the rules of interaction between them. This kind of Environment is classified as ***Qualitative*** Computer Modelling Environments (Gomes, 2008).

METHODOLOGY

To carry out the study was designed an Extension Course with 4 modules lasting 50 min and 1 module lasting 100 min. The data collection instrument consisted of two parts: an Instructional Material, used in the three first modules of the Extension Course with the focus on the Qualitative Computer Modelling Process; and Data Collection Instrument, used in the *Fourth* and *Fifth Modules* to collect data to the study. In the Fourth and Fifth module, students working in peers were asked to build models about two systems: a gas expanding inside a closed room and a predator-prey-like system with rabbits and foxes living in an isolated area. The data collected in these two last modules generated a Data Protocol based on students' peer dialogs while developing the expressive modelling activity, students' peer written material, the video recorded from computer screen, the *ModeLab²* *Log File* with the actions done by students while building models on the *ModeLab²* and the final model structures build by students on that environment.

RESULTS AND CONCLUSIONS

The data collected had inherent qualitative nature and to analyse them was used the Systemic Network technique (Gomes, 2008), where were considered aspects related to the Computer Modelling Process. Results show that all students were able to build models with the Qualitative Computer Modelling Environment ModeLab² based on their own ideas. All models built by students about the Gas Expansion presented the expected behaviour and for the other system was the half of models. This result lend support to the used procedure, *Computer Modelling Process*, which begins with the Steps for Building Models developed ***on paper*** and afterward representing it on the Environment *ModeLab²*: this procedure lead students to think-reflect-organize their own ideas about the target-system for building a first model on paper according to their ideas and subsequently to transfer it to the *ModeLab²* Environment. Regarding to the Tools for Collecting Data and Following-Up the activities development, the results show that they attached valuable and crucial contributions related to the organization, visualization, time consumed for accomplishing the data analysis. An remarkable example was the fact that a small bit of information recorded from screen and audio was lost from one of the peers: the use of the *ModeLab²* Log File facility allowed to rescue the essence of the lost information and not missing it for the whole analysis. These result lend support to the use of the Qualitative Computer Modelling Environment *ModeLab²* for integrating information & communication technologies in Science Classes through expressive or exploratory modelling activities (Gomes et all, 2008; Fehsenfeld & Ferracioli, 2009). The collecting data tools result consolidate the research branch with larger samples focusing on the investigation of qualitative computer modelling in two main perspectives: elicitation of students' conceptions about science topics and the understanding of knowledge structure building process based on causal structures.

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PROBLEM-BASED LEARNING IN MEDICINE

Raja Gošnak Dahmane

University of Ljubljana, Faculty of Health Sciences, Slovenia

raja.dahmane@guest.arnes.si

Samo Ribarič

University of Ljubljana, Faculty of Medicine, Slovenia

samo.ribaric@mf.uni-lj.si

ABSTRACT

Problem-Based Learning (PBL) curriculum in medicine was first introduced in 1969 at the McMaster Medical School in Hamilton, Canada. The first European PBL curriculum was introduced at the University of Maastricht Medical School in 1974. PBL is most often used to facilitate students' integration of basic and clinical sciences and not as a replacement of the standard medical curriculum. During PBL students develop problem solving skills and use relevant facts (triggers) from case studies to define their own learning objectives. The objectives of PBL are to increase knowledge and understanding with the aid of case studies. In addition PBL also facilitates the acquisition of communication skills, teamwork, independent responsibility for learning and sharing information. This paper focuses on the anatomy of tutorial groups and participants' roles. It presents the key steps in the PBL discussion process and the seven jump method. In conclusion, the advantages and pitfalls of PBL are discussed.

Keywords: *problem-based learning, discussion leading, cases studies.*

INTRODUCTION

Many countries have recognized that traditional undergraduate medical education must change substantially in order to match the changing healthcare needs of the population and become centred on the students (Maudsley, 1999; Christopher, Harte & George, 2002). The more recent use of PBL can be traced to North America in the 1960s. A number of medicals schools introduced some problem-based, self-directed, student activities (Harris, Horrigan & Ginther, 1962). But the credit for the introduction of the first PBL curriculum belongs to the McMaster Medical School in Hamilton, Ontario, which was started in 1969 after three years of planning (Neufeld & Barrows, 1974). The first European PBL curriculum was introduced in the University of Maastricht medical school in 1974. This course lasts six years and comprises four years of pre-clinical PBL course and two years of conventional clinical clerkships. PBL has remained a key feature at the University of Maastricht and is used in other degree courses beside medicine – Health Sciences, Law, Business Studies, and Economics.In 1993, three systematic reviews of PBL in undergraduate medical education were published. These reviews, spanning 20 years, were optimistic about the short term and long term outcomes of PBL compared with traditional approaches (Vernon & Blake, 1993). This paper focuses on the anatomy of tutorial groups and participants' roles. It examines the responsibilities of PBL tutors in undergraduate medical curriculum. It presents the key steps in the PBL discussion process and the seven jump method. In conclusion, the advantages and pitfalls of PBL are discussed.

TUTORIAL GROUPS

A good group size is eight to 10 students. The role of the chairperson and scribe should be rotated through the whole tutorial group. The number of sessions and the length of time that the group stays together vary between institutions. Students should stay within a single tutorial group for a block, module or semester, around seven to 14 weeks. A tutorial group may spend one to one and a half hours on a new problem plus one to one and a half hours discussing a previous problem. The role of the chairperson is to lead the group through the process, investigate who the group members are and to introduce them. He has to make agreements with group members about the procedure of the discussion and then introduce the problem for discussion. He must keep to time and maintain the group dynamics. The scribe has the important role of note-taking and recording the points made by the group. He also helps them to order their thoughts.

Tutoring in PBL is quite different from lecturing. Effective tutoring involves knowledge, guidance and requires intense concentration. Discussion leading is an art form. But like all arts, we have to be shown how to do it, and we get better with practice. The strength ob PBL is that it can be vigorous and more engaging than a lecture because students are involved trying to put ideas into their own words. So above all, PBL needs structure and key points. The first key point is advance preparation and giving out the case one or more weeks ahead of time. Then the tutor chooses a case with controversy, "a case is a story with an educational message" and what makes it a good story is controversy. He has to set the scene for the case to warm up the audience before blurting out the first question. He must use a good opening question, involve as many people as possible, and ask NON-threatening questions, control the discussion, correct student error and structure the discussion.

THE SEVEN JUMP METHOD

PBL tutorials are conducted in several ways. In this paper, we are presenting the Maastricht "seven jump" process. For the first meeting there are five steps. At the beginning we have: to identify and clarify terms and concepts not readily comprehensible; the scribe lists those that remain unexplained then, to define the problem to be discussed, the students may have different views on the issues; the scribe record a list of agreed problems, "Brainstorming" session to analyse the problem and offer tentative explanations; the scribe records all discussions, draw up an inventory of explanations; the scribe organises the explanations, formulate learning objective. The group reaches consensus on the learning objectives. The tutor ensures that the learning objectives are achievable, comprehensive and appropriate. Between meetings the students must: collect further information through private study. For the second meeting: they have to synthesize new information, evaluate and test it against the original problem, reflect on and consolidate learning.

PITFALLS AND ADVANTAGES OF PBL

The main lethal pitfalls that must be avoided at all cost are: not understanding how PBL works, poor planning and not doing enough work. Tutors that enjoy passing on their knowledge may find PBL frustrating. The students may be deprived access to a particular inspirational teacher who in traditional curriculum would deliver lecture to a large group (Wood, 2003). PBL is not about problem solving per se, but rather it uses appropriate problems to increase knowledge and understanding. Most students enjoy active participation and consider the process to be relevant, stimulating and fun (Des Marchais, 1993). The learning environment created by PBL is more convivial for students (Blight, 1995). PBL fosters self-directed learning skills (Norman and Schmidt, 1992) and promotes deeper rather than superficial learning. The medical education literature abounds with publications on PBL, which have produced lively debate. But the question remains: does PBL produce better doctors? Choon-Huat Koh and his colleagues (2008) conducted a systematic review of evidence of the effect that PBL during medical school had on physician competencies after graduation. The conclusion is that PBL during medical school has positive effect on physician competencies especially on the social and cognitive dimensions. Future research should look beyond knowledge competency and measure the effect of PBL on other dimensions of physician competency.

CONCLUSION

Problem-based learning is a combination of educational method and philosophy; philosophically is centred on the student and on problem-first learning, whereas in subject learning teachers transmit knowledge to students before using problems to illustrate it. PBL aims to enable students to acquire and structure knowledge in an efficient, accessible, and integrated way. The method involves learning in small groups in a tutorial system. The tutor facilitates the group's self directed generation of learning objectives from triggers in successive case scenarios that set the context. These objectives guide self directed learning between sessions, and then in subsequent sessions students reapply, synthesize, and appraise their learning.

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BRIDGING THE GAP IN LACK OF PROFESSIONAL INSTRUMENTATION – SMALL-SCALE, LOW-COST ANALYTICAL INSTRUMETNS FOR GREATER EQUITY IN LEARNING ANALYTICAL CHEMISTRY

Nataša Gros

University of Ljubljana, Faculty of chemistry and chemical technology
Aškerčeva 5, SI-1000 Ljubljana, Slovenia

natasa.gros@fkkt.uni-lj.si

ABSTRACT

This contribution challenges the often misleading opinion that there is only one way of doing analytical chemistry and that is - with complicated professional and costly instrumentation. A low-cost spectrometer with a microreaction chamber and a tri-colour light emitting diode as a light source is described. The spectrometer can be easily upgraded into several different analytical instruments e.g. a gas and a liquid chromatograph, a flow injection analysis system with the spectrometric detection and a spectrometric microtitrator which all enable sound introduction of fundamentals of instrumental analytical methods by hands-on approach and are suitable for real life applications.

Keywords: *Instrumental analytical chemistry, Low-cost instruments, Hands-on approach, Equal opportunities, Spectrometer*

INTRODUCTION

Rapid technological development requires professionals with excellent analytical chemistry skills to monitor technological processes and their impact on the environment, and to control food safety and people's health. Students currently enrolled at vocational schools of different non-chemical sectors will be even more in need of the knowledge and skills of analytical chemistry, strongly required also by their future employers. Practical work is an essential part of learning analytical chemistry. Professional instruments are very costly and even not always very suitable for teaching the basic concepts of analytical methods. Vocational schools in different sectors and different countries do not have equal opportunities for teaching analytical chemistry, since they are not equally well equipped and do not devote equal parts of teaching time to laboratory work.

The hands-on approach in teaching and learning is believed to contribute to better understanding of the concepts taught. However, this approach is difficult to introduce, if costly instrumentation is required. Therefore even for modules on instrumental analysis at tertiary level of chemical education, activities of the students are in some cases limited only to preparatory phases, while actual measurements are carried out by the demonstrator. The reasons why analytical chemistry is usually neglected at lower levels of chemical education are manifold. Most commercial instruments are expensive and their operation and maintenance are demanding, therefore most secondary school chemistry teachers are not knowledgeable enough to cope with the technology on the one hand and theory on the other.

Possibilities which enable some of these drawbacks to be overcome are simplification and miniaturization of analytical instruments. This contribution describes the low-cost spectrometer with a microreaction chamber and a tri-colour light emitting diode as a light source which can be easily upgraded into several different analytical instruments e.g a gas and a liquid chromatograph, a flow injection analysis system with the spectrometric detection and a spectrometric microtitrator which all enable sound introduction of fundamentals of instrumental analytical methods by hands-on approach and are suitable for real life applications.

METHODS

A starting point for the construction of a tri-colour light emitting diode-based in situ spectrometer was the decision to put polymeric supports, called blisters—and used in the pharmaceutical industry for packaging of pastilles—into the function of reaction and measuring chambers. A prototype of the spectrometer was constructed and the novel optical geometry patented (Gros, 2001).

The specific of the geometry of the spectrometer is that the light of a tri-colour light emitting diode (LED) with emission maximums 470, 565 and 660 nm (blue, green and red light) passes through the solution in the vertical direction and falls directly on a photo-resistor, which lies under the microreaction chamber. A tri-colour LED functions as a light source, the blue, green or red light can be selected. The equality of path length of the light within the series of measurements is achieved by a control over the volume of solutions in individual hollows of a blister, e.g. by using micro-pipettes for measuring the sample and the reagent volumes or by drop based experimental approach. The bottom of the measuring chamber is designed so that it supports the blister in different positions, enabling spectrometric measurements to be made for different hollows of the blister. The measurements are expressed as transmittance (%). Experiments demonstrating additive mixing of colour can also be performed with the tri-colour LED. The prototype was later transformed into more robust and even easier to handle Spektra™ spectrometer by the Laboratorijska tehnika Burnik d.o.o., Slovenia. The Spektra™ spectrometer has emission maxima at 430, 565 and 625 nm.

RESULTS

The spectrometer for educational purposes was upgraded into several other analytical instruments (Gros, 2005, Gros & Vrtacnik, 2005, Gros, 2007) or connected to a personal computer as indicated in Figure 1. Through the two EU Leonardo da Vinci projects “Hands-on approach to analytical chemistry for vocational schools” and “Hands-on approach to analytical chemistry for vocational schools II” several experiments from different chemical and chemistry related disciplines were developed for this equipment and published on the web pages of the projects with acronyms AnalChemVoc and AnalChemVoc II (FKKT, 2008).

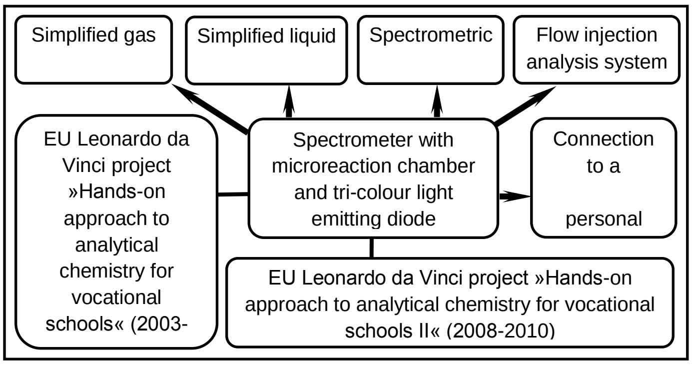

Figure 1. Upgrading of the spectrometer Spektra™ into other analytical instruments and the related EU projects through which several experiments for this equipment were developed

CONCLUSIONS

The approaches described here can contribute not only to more equal and better opportunities for teaching and learning analytical chemistry but can also rise the innovative potential in teachers and students by challenging the often misleading opinion that there is only one way of doing analytical chemistry and that is - with complicated professional and costly instrumentation, and if a school or university does not possess such instrumentation or has no access to it there is no other way.

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THE USE OF WOODLANDS AND GREEN SPACES BY KINDERGARTENS

Inger Hilmo

Oslo University College, Faculty of Education and International Studies

Inger.Hilmo@lui.hio.no

Kari Holter

Oslo University College, Faculty of Education and International Studies

Kari.Holter@lui.hio.no

ABSTRACT

The use of woodlands and green spaces by kindergartens
In our project in kindergartens the main aim was to identify relations between quality of life among children, patterns of usage, attitudes towards nature, preferences, factors inhibiting use, as well as restoration of the greenway area along the Alna river in Oslo. We also wanted to identify culture-specific norms and socialisation factors influencing nature-related activities. Pre-school teachers were asked some questions regarding where they go when they take the children on outdoor excursions, how often and why. Additionally, we had questions on reasons why some parents are sceptical to let their children spend a day out of doors in nature.

Keywords: *Kindergarten, childhood, nature, woodlands, sustainable development*

INTRODUCTION

The Norwegian authorities currently focus on outdoor activities as a pedagogical way of working in preschools. Arguments for this are both related to aspects of sustainable development and health. The hope is that a child who learns to love the nature will wish to preserve it. In our project in kindergartens the main aim was to identify relations between quality of life among children, patterns of usage, attitudes towards nature, preferences, factors inhibiting use, as well as restoration and management of the greenway area along the Alna river in Oslo. We also wanted to identify culture-specific norms and socialisation factors influencing nature-related activities. This project was part of the research project”Down by the Riverside”.

METHODS

In this project we collaborate with the Norwegian institute for nature research (NINA), Norwegian institute for cultural heritage research (NIKU), Norwegian institute for urban and regional planning (NIBR) and the Municipality of Oslo. Our main contribution is a questionnaire distributed to all the kindergartens in the area. We received response from 83 kindergartens, which amount to a response rate of 65 %. We asked pre-school teachers in the kindergartens some general questions regarding where they go when they take the children on outdoor excursions, how often and why. Additionally, we had specific questions on the Alna river area, and also on reasons why some parents are sceptical to let their children spend a day out of doors in nature.

RESULTS

Some of our findings were that more than 90 per cent of the kindergartens spent one day or more per week, outside in the nature during the spring, summer and autumn seasons. All preschool teachers who answered our questionnaire marked that children are interested in animals. The preschool teachers pointed at several advantages for the children (see table 1), and they came forward with suggestions for improving the greenway area along the Alna river. We also received replies that gave information about why some parents are sceptical against having their children spend several hours outdoors in nature.

Our study also points out the importance of good upkeeping and restoration of urban areas. Furthermore, many of our results coheres with results from investigations aimed at schools and the general public in the main project, “Down by the Riverside”.

Table 1

The following display comments about areas in the nature where children can stay during the day

Please compare your experiences from work with children in the kindergarten itself with work in the woods/in the areas along the river	Disagree %	Neither %	Agree %
Children have more opportunities for strengthening their feeling of self-confidence	1,2	3,6	94,0
The opportunities for working with language skills are poorer	79,5	4,8	12,0
Children develop their creativity better	2,4	7,2	87,9
Role play has poorer conditions	78,3	4,8	13,2
Children develop the ability to observe better	0,0	6,0	91,6
Children’s learning improves	1,2	15,7	81,9
There are more conflicts	93,9	3,6	1,2
Girls play more with boys	8,4	32,5	56,6
Boys play more with girls	7,2	37,3	53,0
Children play less with younger or older children	67,5	18,1	12,0

CONCLUSIONS

Our study reports on good developmental possibilities as to language, learning, a feeling of self-confidence and creativity for children who spend time in nature. International research who addresses the importance of nature in children’s lives supports these findings. It is however an obvious need for identifying gaps in current knowledge and to discuss how research questions in this area might be addressed with both care and rigor.

The pedagogical practises are obliged to be in the best interest of the child. Some parents in our study were worried that their children are freezing, might get lost or are not finding anything to do on outings while the preschool teachers valued being outside as an important ideology. These differences in opinions challenges how to include the children’s as active negotiable participants in their own lives.

The Framework Plan for the Content and Task of Kindergartens says that the aim is for children to begin to understand the significance of sustainable development. Further questions to reconsider are: How are outdoor activities connected to sustainable development? How does the pedagogy of today succeed concerning sustainable development?

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TEACHER ASSESSMENTS IN SCIENCE FOR THE COMPULSORY SCHOOL

Nina Hammarberg

Mid Sweden University

nina.hammarberg@miun.se

ABSTRACT

The aim for the study is to examine if the way a question is constructed influences the result among girls and boys. Does it make sense for the results for girls or boys if the question is a multiple choice question or an open response question? To find out if the question format affects the assessment result a first analysis of data from the OECD study Programme for International Student Assessment (PISA) from 2006 has been accomplished. The result reveals that girls perform better when it comes to open response questions and boys are better off when dealing with multiple choice questions.

Keywords: *assessment, PISA, gender*

INTRODUCTION

An essential part of teachers´ work is related to assessment of students´ achievements in their studies. If the curriculum on the national level allows the teacher a high degree of freedom in choosing subject content and methods for teaching, as the Swedish curriculum do, this will also be reflected in the practice of teacher assessments. In a comparison between the Swedish curriculum from 1969 (Lgr 69) and the current curriculum (Lpo 94) the former strictly regulated all school activities while the latter gives a high degree of freedom in organization and realization of teaching (Gustafsson 1999).

This study focuses on Teacher Assessment according to Gipps´ definitions (1994), which are repeated assessments made by teachers in order to build up a broadly-based understanding of the pupils' attainment. When it comes to teacher made paper and pen tests, there are several ways to construct the assessments. Wedman (1988) lists the most common types of questions and organizes them in order from low grade of structure in responses to high degree of structure in responses. Essays are characterized by a low grade of structure while multiple choice questions and right or wrong questions have a high degree of structure. Questions with short open answers are found in the middle of the range.

In the OECD project "Programme for International Student Assessment" (PISA), mainly three types of questions were represented in the main study 2006 where science was the major domain:

- Multiple Choice questions (MC)
- Complex Multiple Choice questions (CMC)
- Open Response questions OR)

Three competencies are tested:

- Explaining phenomena scientifically (EPS)
- Identifying scientific issues (ISI)
- Using scientific evidence (USE)

With the PISA database available the possibility to do a quantitative analyze of the solution frequencies between boys and girls arises as well as the possibility to deepen the insight into what constitutes the differences. In addition to the structural type of question, subject content may result in gender differences. In this stage it is important to emphasize that there are several ways in which the items are categorized in PISA.

The main research question in this study is which parameter is the most important? Question format or competency?

METHODS

In the PISA database questions with a significant difference in solution frequency between boys and girls will be gathered and analyzed in order to categorize differences. For the statistical analysis SPSS will be used as analysis instrument to use question format as dependent variable when controlling for competencies and to use competencies as dependent variable when controlling for question format.

RESULTS

The PISA main study that took place in 2006 with science as major domain included 108 questions (in this study 99 items, 9 items are excluded from the database). In Sweden approximately 4 600 students at an age of 15 years participated in the assessment. A data analysis of the results has shown that in 33 questions there is a difference in results between girls and boys with a significance level of 5 %.

Table 1. Number of questions in science, PISA 2006, with a significant difference in results between boys and girls with respect to question format and competency dimension.

	Type of questions	Number of questions	Girl	Boy
Quest. format	MC	12	2	10
	CMC	11	7	4
	OR	10	8	2
Comp. Dimens.	EPS	15	4	11
	ISI	7	7	0
	USE	11	6	5

When it comes to open responses girls performed better than boys. On the other hand boys performed better in questions of multiple choice formats.

Cross-examination of the variables Question format and Competency for 99 items are presented in table 3 and 4. Critical value for the 5% level of significance for values > 5,991 with 2 df.

Table 3. Competencies as dependent variable when controlling for question format

	Value	df	Asymp. Sig. (2- sided)
Pearson Chi Square	15,645	2	0,000

Table 4. Question format as dependent variable when controlling for competencies

	Value	df	Asymp. Sig. (2- sided)
Pearson Chi Square	4,762	2	0,092

CONCLUSIONS

Eriksson (2005) has in his study from results in TIMSS shown that question format affects the assessment results between boys and girls. This study on PISA data confirms these results if we only consider the results in Table 1. However, the content to be evaluated also plays matter. When a χ^2 test is applied to control whether question format or competency affects the result most, we can no longer se that problems caused by question format are significant. When controlling for question format, competencies are significant and this implies that competencies have a bigger impact on the result than question format, when the variables are cross-examined.

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TRANSFORMING MARS INTO A NEW "EARTH"? STUDENTS' SOCIO-SCIENTIFIC ARGUMENTATION IN A CHAT EMBEDDED IN A DIGITAL LEARNING ENVIRONMENT

Lena Hansson

Kristianstad University College

Lena.Hansson@hkr.se

Andreas Redfors

Kristianstad University College

Andreas.Redfors@hkr.se

ABSTRACT

In a European project, CoReflect, different digital learning environments are developed, implemented, and evaluated. All learning environments focus upon socio-scientific issues. The Swedish group has developed a learning environment focusing socio-scientific issues related to astrobiology. We report from the students' argumentation concerning the question *Should we transform Mars into a planet where humans can live in the future*? The students (16y) work together in small groups. Included in the learning environment is a *chat* function. The focus of this article is on the discussions in the chat, but also arguments used in other situations are discussed and compared.

Keywords: *Socio-scientific issues, argumentation, ICT, astrobiology, secondary school*

INTRODUCTION

Young people's lack of interest in science and science intense educations are a big concern for many stakeholders in western societies (e.g. Sjøberg & Schreiner, 2005). This has led to a call for a renewal of science education, with the aim of making more students feel that science is of relevance and importance for themselves, and for the society as a whole. There has also been an increasing acknowledgement of the importance of scientific knowledge among people, to make an active, and informed citizenship possible. Because of that many researchers in the field of science education suggest that work with "socio-scientific issues" (Ratcliffe & Grace, 2003) should be included in the teaching of science (Sadler, 2004). Including "socio-scientific issues" will prepare young people to deal with questions that they will meet as citizens. It is also a way to make science relevant for greater numbers of students. Yet another strategy to make science more appealing, and promising for meaningful learning, is to integrate new technologies (ICT) in the teaching.

In the CoReflect project (**www.coreflect.org**) – groups in Cyprus, England, Germany, Greece, Israel, Sweden and the Netherlands are developing, implementing and evaluating teaching sequences using the web-based platform STOCHASMOS (Kyza & Constantinou, 2007). The interactive web-based inquiry materials support collaborative and reflective work. The project methodology is based on the idea of design-based research. All learning environments are focusing "socio-scientific" questions. In the article we report from the implementation of the Swedish learning environment. The learning environment is focusing socio-scientific issues in an astrobiology context. Students are working with two driving questions. One of them: *Should we transform Mars into a planet where humans can live in the future*? is focused in this paper. This socio-scientific issue includes e.g. scientific aspects (Is it possible?, Different ways to proceed? etc), economical aspects (Resource priority?), social aspects (e.g. Safety? Who will go?), and ethical aspects (Is it alright to interfere in other planets? Hybris?). During their work with the learning environment the students collect and formulate arguments (for and against) concerning different aspects of the driving question, using a special template included in the workspace of the learning environment. Included in the web-based platform is also a chat function.

The aim of this article is to describe the kind of arguments used in the students' chat when discussing the driving question. The arguments used and discussed in the chat are related and compared to the arguments that have been formulated by the students during the teaching sequence, and are also compared to the arguments used in the students' final standpoints, written the lesson after the chat took place.

METHODS

The students working with the learning environment are in their last year of compulsory school (16 years old), and work together in small groups (2 or 3 students in each group). Each group worked in front of one computer. The chat reported from was the second to last lesson during the teaching sequence. The student groups were paired by the teacher. The oral discussions within each group while chatting with another student group, were audio taped. All computer activities were logged by STOCHASMOS. The arguments that the students have collected and written in the workspace of STOCHASMOS, as well as their final standpoints on the issue, are therefore available for the researchers. Also the chat is logged. In addition to this researchers were present in the classroom during the "chat lesson", observing the lesson and taking fieldnotes.

RESULTS

Working with the learning environment the student groups collect different kinds of arguments (scientific, economical, social, and ethical arguments). During the chat the students used these when discussing whether or not we should transform Mars. The teacher felt that the students would need some scaffolding to focus on relevant questions. She therefore provided some questions (aspects of the main question) that could be discussed during the chat. The students enjoyed the chat as a way to discuss the driving question. However, the discussions turned out in different ways. The preliminary results suggest that students frequently use science in their chat. Some groups do not use very many arguments (concerning different aspects of the issue) in the discussions, while others use a lot of different arguments. In the final standpoints, written the lesson after the chat, the students use arguments related to risks, costs & resources, curiosity, possible development and ethics. Much of this is related to science. In the presentation during the conference we will also present results concerning how the content and arguments used during the chat are related to the arguments that the students have formulated using the template "collected arguments" during the teaching sequence, as well as to the arguments used in the final standpoints.

CONCLUSIONS

Both the students and the teacher liked the chat. It was obvious that it was a familiar tool for the students. The teacher saw it as a good possibility for the students to develop their argumentation, and to practice formulating the arguments in written text. We saw that the students used different kinds of arguments in the chat, also arguments based on science are frequent. This results differ from other results that have found that science is not, at least not core science, considered relevant by the students when discussing and making decisions on socio-scientific issues (Aikenhead, 2006). However, we can also see that the discussions in the chat turn out in different ways for different group-pairs. Some chats cover different aspects of the issue, while others focus upon one or few aspects. The experience from the implementation of the learning environment suggests that including a chat activity have the possibility of making the students engage in the discussions, but also that some of the students found support in the scaffolding questions from the teacher.

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SUBJECT MEETS SUBJECT: A STUDY ABOUT TEACHERS' INTERCHANGE IN EDUCATION FOR SUSTAINABLE DEVELOPMENT

Helen Hasslöf

School of Teacher Education
Malmö University, Sweden

helen.hasslof@mah.se

Margareta Ekborg

School of Teacher Education
Malmö University, Sweden

margareta.ekborg@mah.se

ABSTRACT: SUBJECT MEETS SUBJECT

The aim of this study is to investigate the significance of interdisciplinary meetings between teachers for the interdisciplinary interpretation of ESD. This study takes its point of departure at a literature seminar between seven teachers at an in-service course of ESD at Malmö University. What different aspects are emphasized and how do the teachers use each other's knowledge as resources? What do different teachers consider as important aspects of the discussion? The preliminary results show that the social aspects and questions with ethic and moral based entrances are dominating the discussion. The ecological perspectives are mostly treated as fact-based knowledge.

Keywords: *ESD, interdisciplinary, collaboration, ESD-content, science education*

INTRODUCTION

Environmental education has been a topic for biology teachers in Sweden, as well as in many other countries, since the 1970th. In order to meet the goals in policy and school documents about ESD, environmental education is supposed to broaden the view and embrace different aspects and competences. ESD seeks to integrate ecological, social and economic perspectives into environmental education. Studies emphasizes the necessity of the teacher's own ability to possess "holistic views", "complex thinking" and "pluralistic attitude", since these are important pieces of the pedagogical content knowledge (PCK) for ESD. To meet these claims teachers need a broad understanding of ESD.

Studies show that collaborative reflection can provide greater clarity to issues than can be individually perceived (Rearick & Feldman's, 1999). Learning in collaborative settings is particularly enhanced when people with different ideas, conceptions, and opinions interact. In collaboration, existing knowledge extend and new knowledge can be created (Putnam & Borko, 2000). However, interdisciplinary teaching is not free from problems. Several studies show the difficulties of interdisciplinary teaching in school. On the other hand when teaching for sustainable development in mono disciplinary subjects there is difficulties for the teachers from natural science to include aspects like values in science, and critical attitudes. Similarly teachers from the social science have problems to discuss environmental questions with the demand of natural science knowledge. Studies about lectures' beliefs and attitudes from higher education shows that teachers often place ESD equal to ecological sustainability (Summers & Childs, 2007). This indicates a lack of understanding how the ecological, economic and social aspects are intertwined in ESD. Though collaboration is considered a powerful professional development environment for teachers, little empirical research has been done into how teachers learn in collaborative settings.

METHODS

The study takes its point of departure at a literature seminar at an in-service course where teachers reflect on sustainable development together in an interdisciplinary setting. Due to Wertsch (1991) learning and meaning making are defined as processes taking place in social contexts, with the language as a main artefact. Learning is mediated through communication between individuals. In this study teachers reflect together in a social context with possibilities to use knowledge form each other. This is in line with the view of learning and development as a transition from a social context into individual understanding in social situations. While the conversation continues the communication makes sense for the participants. This study use a sociocultural perspective which means one ought to start investigating the ways in which people think by looking at how they *talk* and *communicate.*

Research questions

- What different aspects are emphasized by teachers in an interdisciplinary discussion about sustainable development, and how? Which role has the ecological perspective?
- How do the teachers use each other's knowledge as resources?
- What do different teachers consider as important aspects of the discussion?

The seminar group that was subject for this study consisted of seven teachers that normally work in public schools in Malmö with pupils age 13-15. The teachers represent different subjects: natural science, social science, language, mathematics and home economics. The literature seminar was videotaped and audio recorded, semi-structured interviews were used after the discussion. The transcripts from the seminar and the interviews are now the subject of analysis and the results will extend during this spring. A form of content analysis is used which play attention to what different dimensions of ESD that emerge and if there is a tendency to pick them up and treat them as intertwined. Bakhtines (1986) framework is used to analyse the conversation. The transcripts from the interviews will also be analysed in a qualitative content analysis.

RESULTS

Initial analyses reveal that the social aspects and questions with ethic and moral based entrances are dominating the discussion. The ecological perspectives are mostly treated as fact-based knowledge. This implies that the ecological questions is not as dominating as supposed in environmental discussions, on the other hand it seems like the lack of value oriented aspects in the natural sciences seems to be confirmed in those preliminary analyses. The teachers pick up each other's words and statements, to use for their own argumentation. Further analyses of those data are currently underway. The findings will be discussed in relation to the signification and goals of achieving an interdisciplinary approach of ESD.

CONCLUSIONS

For the international research field this study hopefully can give a complementary piece of understanding to the ESD research field, by illustrating the outcome of interchanges between teachers in relation to integration of the three dimensions of ecology, economy and social questions. Since the research about teachers' learning is not investigated to a great extent, this study could be a complement. The result/findings of this study might reveal a view of the importance of how teachers can develop a more complex understanding of ESD through reflection in a social interdisciplinary context. *To be revised and continued when the results and the analysis expand during this spring…*

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PROBLEM BASED LEARNING (PBL) FROM THE PERSPECTIVE OF SOCIO-CULTURAL LEARNING THEORIES

Carola Hernández Hernández

Aalborg University/PhD Student

chernan@learning.aau.dk

ABSTRACT

The socio-cultural views of learning in science have led us to rethink the ways to learn and teach these areas in all educational levels. The problem-based learning (PBL) has been developing since the 70s as a proposal of situated learning in different universities. In particular, Aalborg University in Denmark has developed its own model of PBL. This paper aims to present an initial exploration of the PBL model in the faculty for Engineering, Science and Medicine at the Aalborg University, the principles on which it is based, and whether these can be consistent with socio-cultural views of learning or not.

Keywords: *Problem Based Learning (PBL), socio-cultural perspectives on science, science education at university level.*

INTRODUCTION

Leach and Scott (2003) argue that adopting a socio-cultural perspective on science education implies viewing science, science education, and research on science education as human social activities conducted within institutional and cultural frameworks. Radford (2008) shares this perspective and suggests a view of teaching and learning anchored in the idea that learning is a social activity (praxis cogitans), deeply rooted in historically constituted cultural forms of thinking and being. And they conclude that it means seeing the scientific study of the world itself as inseparable from the social organization of the scientists' activities. These ideas involve rethinking the ways of learning and teaching science at all educational levels, particularly at the university level.

In recent years, higher education has been an interesting field for research because the object of study is the institutional foundation of all academic disciplines and the contribution of systematic knowledge to the future of society. In the 70's some universities that developed their curricula on problem-based learning (PBL) as McMaster University (1969) in Canada, Aalborg University (1974) in Denmark or Maastricht University (1976) in the Netherlands became visible. These institutions have been closely watched because of their innovative curriculum and student-centred ways of teaching in many professional fields, such as medicine, engineering, science, or law.

Problem-based Learning is a pedagogic model consistent with a current philosophical view of human learning, which argues that knowledge is situated: it is part and product of the activity, context and culture that developed and used this knowledge (Barrows, 1996; Vygotsky, 1978, 1986). In the PBL model, students in small teams explore a problem situation, and through this exploration, they are expected to identify the gaps in their own knowledge and skills, so that they will decide what information they need to resolve or manage the situation with which they were presented (Barrows & Tamblyn, 1980). Thus, in this model the problems are used as the starting point to generate curiosity and motivation about the new knowledge; students assume responsibility for their own learning, and teachers change their role from instructor to facilitator (Barrows, 1996). This model contrasts with case-based learning where the problem is presented after the topic is covered to test the understanding and support synthesis (Savery & Duffy, 2001).

However, there are differences in how problem-based learning models are practiced and every university has its own way to implement it. There are some studies that argue that the McMaster model is consistent with socio-constructivism (Barrows & Tamblyn, 1980; Savery & Duffy, 2001). Thus, the Aalborg PBL model has not developed on the basis of a consistent compressive theoretical understanding. Instead, it has developed on the basis of a number of – often isolated - theoretical principles, which have found their way to a pragmatic development (Annette Kolmos, Flemming K. Fink, & Krogh, 2004). Therefore, the purpose of this paper is to explore whether these principles can be consistent with a socio-cultural view of learning.

METHODS

I conducted a literature review to characterize the PBL model developed at Aalborg University and to find out which are the underlying principles. In particular, I concentrate in the way that this model is understood in the faculty for Engineering, Science and Medicine to analyze their pedagogical assumptions. Finally, I try to find out if these principles can be consistent with the proposals from a socio-cultural view of learning.

RESULTS

The Aalborg PBL model is a combination of a problem-based learning (PBL) and project-organized approach (POL). In particular, in the faculty for Engineering, Science and Medicine the learning of process competences is considerably supported by the PBL-POL. These competences cannot be acquired only through mental processes. They involve other abilities and they represent a meta-cognitive level of both action and knowledge. Kolmos, Fink and Krogh (2004) show that the PBL class is organized in groups where the students: analyze and define problems within an interdisciplinary subject frame, develop a project during the semester, work together on their project, and submit a common project report. However, they are evaluated individually. The group formulates the problem in the project but there is always a supervisor who approves it. This brief overview makes it clear that there are three theoretical dimensions underlying this model: the problem, the content and the team. Once these three elements are identified, I try to show some of the reasons why they are consistent with a socio-cultural view of learning.

The first element, the problem, is the basis to develop motivation and it determines the direction of the learning processes. Nevertheless, a problem only exists in a social context and it expresses contrasts or conflicts in a specific culture or view of the world. For example, Leach and Scott (2003) show that the development of scientific knowledge (which involves the resolution of the problems and generating new ones) is not only constrained by empirical data, but it is also socially validated by the scientific community. The second element, the content, takes a different approach: it is especially concerned with interdisciplinary learning and exemplary practice. This view enables a direct relationship between theory and practice because the learning process involves an analytical approach using theory in the analysis of problems and problem solving methods. In a socio-cultural view of learning, the learning occurs while the subject participates in socially structured practices and appropriates them (Radford, 2008). And finally, most of the learning processes take place in groups or teams where students discuss, negotiate and learn from their project and in their project permanently. According to socio-cultural theory, dialogue in a learning setting plays an important part in helping learners to *internalisation* ideas and knowledge from the social plane (Vygotsky, 1986).

CONCLUSIONS

A first exploration of the PBL-POL model of Aalborg University suggests that the pedagogical principles on which it is based are consistent with socio-cultural views of learning. In particular, on the faculty for Engineering, Science and Medicine the development of process competences is the core of helping the students to be able to work as a part in a project-working environment. In this sense, the model PBL-POL introduces and supports students in the appropriation of the language and culture of their professions.

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A STUDY OF YOUNG CHILDREN'S COGNITION OF SPACE

Wen-Tung Hung

Meiho Institute of Technology,Department of Nursing

x00000023@meiho.edu.tw

ABSTRACT

The aim of this study was to explore young children's conceptions of space. We analyzed the concept of space in teaching materials, integrated the experts' concepts and developed a map of space and six science activities. We observed and recorded the children's performance through the science activities, and then interviewed eight children individually to confirm their cognitive performance. The major findings were: 1. The concept of space in current teaching materials focuses a great deal on direction, plane, and dimensions, but lacks teaching logical thinking, body motion and time. 2. Young children's linguistic language abilities have major effects on their cognitive performance. 3. Young children perceive special concepts through sight and different sensations result in different judgments.

Key words: *early childhood, individual interview, science activities, concept of space*

INTRODUCTION

The spatial concept is integrated into the curriculum of general knowledge in Taiwan. This general knowledge includes 1. The comparisons of numbers, quantity, and shapes. For example: big vs. small, much/many vs. little/few, long vs. short, light vs. heavy, thick vs. thin, and high vs. low. 2. Knowing basic shapes. For instance: square, triangle, rectangle, circle, etc. 3. Positions, such as top vs. bottom, in front vs. behind, or front vs. back, and left, middle vs. left.

According to Hung (2007), a child under normal cognitive development could discriminate the ideas of top vs. bottom at the age of three, in front vs. behind at the age of four, and left vs. right at the age of five or above. A six-year-old child was capable of viewing space and position as a constant whole. Chen (2005) demonstrated that the conception of space was an essential cornerstone for learning geometry and that the perfect time for children to learn cognitive space was in the phase of early childhood.

METHODS

This study was conducted with judgmental sampling. 66 participants were recruited for the study from a preschool in Kaohsiung City, Taiwan. Researchers recorded the children's spatial concepts by observing them playing freely. Of the sample of participants, 8 children were interviewed. Free play science activities, including direction, plane, dimensions, logical thinking, body motion, and time were created to explore young children's spatial concepts.

RESULTS

A. Direction:

Nearly 80% of the children were correct in the concept of inside vs. outside; as to top vs. bottom; approximately 55% were correct. However, only 44% were right in the concept of in front vs. behind.

B. Plane

About 94% children identified circles and triangles correctly, but were confused with rectangles and squares, where just 73% of the children expressed the right answer. In demonstrating a figure with their hands, 74% children performed better demonstrating a circle, 29% could perform well showing a square with their hands, 44% had correct responses about a rectangle, and about 38% were more accurate with a triangle.

C. Dimensions

Nearly 76% of the children could understand the concepts well regarding space and high vs. low and could perform demonstrating the shapes with their bodies.

D. Logical thinking

Almost 36% of the children were able to present the order from big to small and vise versa, while 32% were subject to partial mistakes.

E. Body motion & Time

Approximately 85% of the children could predict the speed of the ball accurately. It is clear that most children have the ability to sense speed correctly, while 40% could succeed in the first time in rolling a ball, 25% succeeded the second time, 10% succeeded on the third attempt, yet the remaining 25% failed.

CONCLUSIONS

The teaching materials for kindergarteners today concentrate on size and direction, but have less emphasis on position. As to geometry, the materials emphasize plane geometry: for instance, plane shape, one dimension and two dimensions. This study suggests promoting children’s spatial cognition and development with the manipulation of three-dimensional items.

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NEGOTIATING LIFESTYLES? HOW PRIMARY SCHOOL STUDENTS DISCUSS THEIR IMPACT ON GLOBAL WARMING

Malin Ideland

School of Teacher Education, Malmö University, Sweden

malin.ideland@mah.se

Claes Malmberg

School of Teacher Education, Malmö University, Sweden

claes.malmberg@mah.se

ABSTRACT

Researchers claim that school has failed to empower children as citizens of the future. To develop a new approach for planning educational practices we need to bring in the students' diverse backgrounds in classroom discussions. But in what ways is this possible to do? The aim of this paper is to analyse how children from different socio-cultural contexts bring in their interests, experiences and knowledge in discussions about climate change and reduction of CO2.

The data come from a study in which >100 students have discussed global warming from an everyday perspective in focus-groups is used. Five schools, situated in districts with different socio-economic status in the city of Malmö, Sweden have been involved in the study.

Two different themes stand out as important for the students' discussions; a) effective ways to lower carbon dioxide emission; b) consequences for the students themselves and their families. The discussions reveal that children's way to reason in controversial issues are related to their everyday life, they are trying to legitimate their own habits at the same time as they discussing possible sacrifices. Their different living conditions are mirrored in the way they consider the problem, but also in their way of discussing.

Keywords: *Primary science, global warming, socioeconomic status*

INTRODUCTION

There is an increasing emphasis on educating young children to citizens of a global society (Dillon & Osbourne, 2007). However, despite the rhetoric, many researchers claim that school has failed to empower children as citizens of the future (eg Aikenhead, 2006; Claxton, 2008) and to help them to develop knowledge and skills that would be relevant for their living conditions (Hedegaard & Chaiklin, 2005). Among possible reasons for this are teachers' lacks of confidence when dealing with controversial issues, conflicts of interest and in young children's abilities to discuss (Driver et al, 2000, Oulton, et al. 2004). On the other hand, research suggests that school science to a higher extent should take departure from complex, authentic cases involving conflicts of interest – socio-scientific issues (Jensen & Schnack, 2006; Ratcliffe & Grace, 2003). Research also points out the importance of social learning in form of collaborative meaning-making (eg Mercer et al, 2004).

The aim of this paper is to analyse how children from different socio-cultural contexts bring in their interests, experiences and knowledge in discussions about climate change and reduction of CO2.

METHODS

The paper will present data from a study, in which 10 years old primary school students have discussed global warming from an everyday perspective in focus-groups. Five classes have been involved in the study. The schools are situated in Malmö in districts with different socio-economic status. The research interest is on how 10 year old students from different socio-cultural contexts discuss complex issues and how they make connections between a school task concerning global warming, their own interests and societal interests.

The classes were divided in groups of four students. The group task was to choose two among four different suggestions on how to lower carbon-dioxide emission. This followed by writing a letter to the Swedish Minister for Environment involving their suggestions. The students made also a drawing of either a problem with or a possible solution of the global warming issue. All discussions were audio-taped, transcribed and analysed from a discourse psychology-perspective, e.g. how the children make use of different interpretative repertoires – culturally available sets of statements (Wetherell and Potter, 1987) when legitimating their own behavior at the same time as they make personal sacrifices.

RESULTS

Two different themes stand out as important in the students' discussions; a) knowledge about effective ways to lower carbon dioxide emission; b) consequences for the students themselves and their families. The discussions reveal that children's way to reason in controversial issues are related to their everyday life. Their different living conditions and socio-economic status are mirrored in the way they consider the problem. When they negotiate with themselves and reflect over how much they are willing to sacrifice they often try to legitimate their own way of living by bringing in arguments which support their own way of living. We can also see how their socio-cultural contexts are reflected in their way of discussing. Ethnic Swedish children from an academic middle class seem to be more used to discuss and argue than children from a foreign ethnic background and a low socio-economic status.

CONCLUSIONS

By discussing "real world problems" in terms of personal sacrifices and societal consequences the complex issues become possible to deal with for both teachers and students. What is learned has a value outside school. We claim that through bringing in authentic cases, and letting the students negotiate their different perspectives, the school might have a possibility to mentally prepare the students to take action in the future. Wood (1998) suggests that in order for children to be empowered and participate in making choices, they need to practice making decisions through the curriculum. This project is investigating the barriers and affordances for productive student talk in primary classrooms when handling complex socio-scientific issues.

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SHOULD THE INTELLECT, EMOTION AND PERSONAL BELIEFS OF LIFE SCIENCES STUDENT TEACHERS BE EXPLORED AND CHALLENGED?

Angela James

University of KwaZulu-Natal

jamesa1@ukzn.ac.za

ABSTRACT

This paper presents a theoretical argument for teacher professional development that takes heed of the holistic development of student teachers. During their professional development student teacher's intellect, emotion and personal beliefs are explored, recognised, challenged and developed. This is possible if teacher professional development focuses on a paradigm shift in the thinking and actions of student teachers, construction of theory, authentic learning and reflective practice. Student teachers can then be expected to be facilitators of learning who can work with diverse cultural, racial and social groups of learners.

Keywords: *professional development, facilitation, learning, student teachers*.

INTRODUCTION

In South Africa, national educational concerns have identified a poor education system for poor education quality. This poor education is due to in many instances to "poor quality teaching (Paton, 2006, p. 1). Moreover, according to Soudien (2007, p. 188) it is also concerned with "the impact it [the country] is making on the *quality* of the learning". Morrow (2007, p. 184) is of the opinion that "we urgently need to improve the quality of teaching and learning in our schooling system".

A particular action that can be taken to address these issues is to develop a teacher education programme that focuses on the holistic development of student teachers. This programme should aim for student teachers to achieve the highest possible quality of professional practice. It is within this programme that the professionalism required of student teachers to be holistically developed, This is possible if their intellect, emotion and personal beliefs are explored and recognised, and then challenged and developed.

In South Africa our education is in dire need of serious transformation. This transformation is necessary as the results of two major international research studies, namely: the performance of Grade 8 learners in the Trends in International Mathematics and Science Study (TIMMS) of 1995, 1999 and 2003 (Howie, 2001, 2004; Reddy, 2006) and Grade 4 learners' performance in the Progress in International Reading Literacy Study (PIRLS) in 2006 (Mullis, Martin, Kennedy and Foy, 2007), where South African learners had the lowest scores amongst 40 and 50 countries, respectively. This transformation and renewal of education should "start and end with the teacher" (Morrow, 2007, p. 209). Teachers remain the crucial interface between education policy that demand quality education and the execution of this quality (Fullan, 1982). Hargreaves (2003, p. 136) suggests that changes required from policies (or any other relevant authority for that matter) "should be inherent in teacher professional development." In addition, the quality of teacher education itself has to emulate the quality education expected from teachers as a trademark of its professional development.

An approach to teacher professionalism could focus on student teachers constructing their own knowledge about how to teach through the notion of phronesis which Kessels and Korthagen (2001, p. 27) define as “perceptual knowledge, the practical wisdom based on the perception of a situation”. Essentially, for student teachers to be able to construct a phronesis of facilitating learning of school learners, they would need to experience facilitating learning. This construction of theory would have to be a personal activity as each individual’s conceptual structures are not the same (Von Glaserfeld, 2001). Since each student teacher is not given a recipe on how to facilitate learning by an external other, he/she is expected to construct it. In constructing a phronesis of facilitating learning, each student teacher is expected to use his/her experiences of teaching and learning and, most importantly, to integrate these with educational theory. The challenge therefore is for us to respond to how student teachers construct this theory.

Student teachers could construct this theory if they experience authentic learning, which is concerned with experiential, active, professional and contingency learning (James, 2009). The focus of this learning is on student teachers learning in real-life contexts and situations where they are expected to construct a phronesis of facilitating learning in practice. This can only occur if they “use the real world as [their] classroom” (Dryden & Vos, 1999, p. 26) to facilitate learning.

The provision of authentic learning is a requirement for the student teachers construction of a phronesis of facilitating learning but it does not presuppose that they will do this. A factor that could impede this process is the student teachers’ “own preconceptions about learning and teaching.” (Korthagen, 2001, p. 255).

This paper addresses these issues and makes suggestions about what is possible in the South African context and the implications of this for improved quality of education. Since teachers are exposed to diverse learners and teaching contexts, changing curricular and new subject content, it is necessary for student teachers to be professionally developed to work with these changing dynamics.

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MANAGEMENT OF TECHNOLOGY: ARE TEACHERS SUPPORTING SUSTAINABLE DEVELOPMENT STRATEGIES?

Aleksander Janeš

University of Primorska,
Faculty of Management Koper, Slovenija

aleksander.janes@fm-kp.si

Slavko Dolinšek

Institute for Innovation and Development
University of Ljubljana,

slavko.dolinsek@iri.uni-lj.si

ABSTRACT

We currently live in the threshold of the most important scientific, technological and industrial revolution in the development of mankind. The future belongs to those who are able to connect the knowledge on the most advanced technologies with the best practice, strategic management, business and marketing skills. To provide the necessary skills in this area, it is appropriate that a field of teaching and research that one may call management of technology (MOT) is developed. Therefore a real challenge for academia, government and industry is: how to provide industry with the youth educated managers that will develop and carry out the future manufacturing strategies.

Keywords: *technology, management, knowledge, academic program, evaluation.*

INTRODUCTION

Technology is the driving factor which is the cause of biggest changes in our everyday life. Technology is also one of the key means companies use to remain competitive, be included in the labor market, keep contact with their customers and form enlarged partnerships (Hancock et al. 2002; Schilling 2005; Janeš and Dolinšek 2009).To provide the necessary skill base in this area, it is appropriate that a field of MOT is developed (Dolinšek 2004b). Apart from managing innovation processes at research and development, it includes also the introduction and the management of new technologies, products, production processes and other related functions in the company (Tidd et al. 2001). It refers to daily operative activities and strategic questions (NRC 1987). That is why MOT is a demanding and wide discipline which includes the interdisciplinary knowledge of technologies and management. Managers, facing technological challenges daily, must be able to respond promptly and adequately, which requires new knowledge and brings about new tasks. Basic processes of MOT or the tasks of technology manager are: identification, selection, acquisition,use and protection of technology (Khalil 2000).

MOT AS AN INTERDISCIPLINARY FIELD OF STUDY AND RESEARCH

Most comprehensive review of research and academic programs of MOT was done by the IAMOT (International Association for Management of Technology). The census included analysis of 148 international academic programs on MOT and it concludes that the titles and the content of these programs vary significantly (Kocaoglu et al. 2003). Given this diversity, an initiative was launched in 2001 to find common ground for MOT and to establish the credibility of the discipline. Numerous international organizations (i.e. IAMOT, Technology Management Education Association, et al.) participated in this debate. A Credo for MOT (2004) was produced. In accordance with this proposal, MOT academic program should have three components (Van Wyk 2004): accepted range of management specialties, knowledge of technology itself and of technology related management procedures and the contextual setting of MOT. MOT academic programs address technology at an operational, at a strategic and at a policy level (Nelson 1995).

MOT ACADEMIC PROGRAMS IN SLOVENIA

In Slovenia, MOT topics are currently being taught only as a subject or part of the discipline within other study programs (i.e. International Postgraduate School at Institute Jožef Stefan,et al.). On 17 March 2006, the HE council of Slovenia gave its approval to the proposed 2nd level program of the University of Primorska Faculty of Management Koper (UP FM). With this, UP FM is the first HEI in Slovenia that has obtained also accreditation for implementing the MOT program according to the Bologna model. Student acquires general managerial knowledge and that specialized knowledge which enables him to successfully master technology. Postgraduate program MOT is designed for the continuation of undergraduate studies (Dolinšek 2004a).

METHODOLOGY

Students who participated into the survey were from undergraduate program and participants of the (UP FM) MOT course. The questionnaire was developed for the purpose of research the perception of the students and monitoring the development of MOT course. Main research question is what is the added value of MOT course (students satisfaction) seen from the students' viewpoint? Questionnaire was divided into four sections: course organization, course contents, course study materials and students estimation of lecturers. Some questions were open and some questions were consisted of a five point scale from 1 (poor) to 5 (excellent). Answers were analyzed quantitatively with the factor analysis method. Survey was performed in the 2006/07 academic year.

EMPIRICAL FINDINGS

For development and improvement of the MOT course we performed survey which we conducted in three study centers of the FM i.e. Nova Gorica, Škofja Loka and Koper (SCNG, SCŠL and SCKP). The results are shown in the table 1 below.

Table 1. Factor models and reliability by Study Centre's

Study Centre	P.Corr.	KMO	Sig.	Comm.	%Var.	Factor	Reliab.	N
Organization	-	0,794	0,000	>0,45	74,202	Org.satisf.	0,882	31
Contents	-	0,840	0,000	>0,48	73,635	Con.satisf.	0,907	31
Study Material	-	0,828	0,000	>0,6	70,310	SM.satisf.	0,888	31
SCNG Sum	good	0,790	0,000	>0,6	61,744	overall satisf.	0,950	31
Organization	-	0,776	0,000	>0,45	68,308	Org.satisf.	0,842	24
Contents	-	0,710	0,000	>0,6	68,829	Con.satisf.	0,883	24
Study Material	-	0,880	0,000	>0,5	77,894	SM.satisf.	0,926	24
SCŠL Sum	good	0,621	0,000	>0,8	59,712	overall satisf.	0,946	24
Organization	-	0,481	0,049	>0,5	67,585	Org.satisf.	0,800	7
Contents	-	-		-	-	-	0,143	7
Study Material	-	-		-	-	-	0,462	7
SCKP Sum	low					-	0,692	7

Note: Used Extraction method was Principal Axis factoring or Maximum likelihood.

Main picture consisted from the factor analysis result is the confirmation of the successful harmonization of MOT course with the principles of the MOT Academic Program suggested by Credo for MOT (2004). Factors from analyses confirmed the satisfaction of students with the course organization, contents and study materials (see table1).

CONCLUSION

The fact is that the pace of technological development is so extensive that theoretical and professional knowledge is fast becoming obsolete. Quite obviously, technological development and globalization has a huge influence on the requirements of the economy to have a different kind of graduates, which cannot be provided by avoiding MOT. Therefore a real challenge for academia, government and industry is: how to provide industry with the human capital that will develop the future manufacturing and service strategies. To do that, universities need to develop a new generation of manufacturing curriculum with professors, who understand the future industry and the need to attract youth with an interest in technology.

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NORWEGIAN TERTIARY STUDENTS' VALUES AND PRIORITIES FOR EDUCATION AND FUTURE JOB: GENDER DIFFERENCES AND IMPLICATIONS FOR RECRUITMENT

Fredrik Jensen

Norwegian Centre for Science Education

fredrik.jensen@naturfagsenteret.no

Camilla Schreiner

Norwegian Centre for Science Education

camilla.schreiner@naturfagsenteret.no

ABSTRACT

Results from the research project "Vilje-con-valg" indicate that all Norwegian tertiary students have in common that they want to do something interesting, meaningful, self-realizing and self-developing in their education and future job. They also want safe jobs and a good salary. To a larger extent than boys, girls want the education to be adjusted to their own skill level and they want personal guidance from their teachers or supervisors. Girls have less confidence in their own abilities to succeed in science, technology, engineering and mathematics (STEM) subjects, which might be an important factor keeping girls out of science and technology education. They also put emphasis on meaning, idealism, helping other people and benefiting the society in their future jobs. It may be suggested that recruitment initatives should make it visible that STEM disciplines fit with the values and priorites of today's youth. Initiatives should show that these disciplines offer interesting, meaningful and self realizing career options, and safe jobs and reliable income. Efforts directed at girls should show them that they can do something meaningful and idealistic through a career in STEM. It could also be fruitful to develop more long-term initatives aimed at enhancing girls' expectation of success.

Keywords: *Recruitment, tertiary education, gender*

BACKGROUND AND AIMS

In Norway and other countries in the Western world there is a lack of students in science, technology, engineering and mathematics (STEM) disciplines (EU, 2004). In order to develop successful recruitment initatives, knowledge of adolescents' priorities and wishes for education and future job is valuable. This presentation is based on the Norwegian research project "Vilje-con-valg", which aims to describe young Norwegians' values, wishes, prioritities and aspirations related to their career choices.

Students' values, priorities and wishes for education and future job will be looked at by comparing responses across different disciplines, in order to see what they have in common and how they differ. Focus will also be given to differences and similarities between girls and boys. Finally, implications for future efforts at recruiting more people into STEM disciplines will be discussed.

DATA SAMPLE, METHOD AND THEORY

Vilje-con-valg survey data was collected fall 2008. The target population is first term students in tertiary education on STEM subjects, and students from some non-STEM subjects for comparison. This presentation focus on the students responses on questions in the questionnaire such as: How important are the following for your future job?, which has a list of items the students answer by ticking off on a four level Likert scale from “not important” (coded with value 1) to “very important” (coded 4). The mean scores are compared across ten different disciplines: marine technology (bachelor’s and master’s programme), engineering, graduate engineering, biology, science and mathematics, nursing, veterinary, media and also economy and business administration. All presented results are statistically significant and interpreted as interesting.

The findings from Vilje-con-valg will be discussed in light of Inglehart (1990, 1997), who describes our society as post-materialistic. He finds that values such as democracy, justice, environment, and creativity are more important to youth of today than traditional values such as earning money and accumulating goods.

RESULTS

All students, regardless of discipline, reported they wanted to do something interesting, meaningful, self-realizing and self-developing in their education and future job. For these items the mean scores are 3,0 and above. Students from all disciplines, both STEM and non-STEM, also put some emphasis on safe jobs and a good salary, with mean scores around 2,7 on these items.

To a larger extent than the boys, girls want the education to be adjusted to their own skill level and they want personal guidance from their teachers or supervisors. Girls have less confidence in their own abilities to succeed in the education they have started on. Girls’ low expectation of success are also documented in other studies (for example Kjærnsli, Lie, Olsen & Roe, 2007; Simpkins, Davis-Kean & Eccles, 2006). To a larger extent than boys, girls put emphasis on meaning, idealism, helping other people and benefiting the society in their future jobs.

DISCUSSION AND POSSIBLE IMPLICATIONS FOR FUTURE RECRUITMENT INITIATIVES

It may be suggested that recruitment initatives should make it visible that STEM disciplines fit with the values and priorites of today’s young people. The initiatives should show that STEM offer interesting, meaningful and self realizing career options. At the same time it might be fruitful to emphasise that such careers offer safe jobs and a reliable income.

Inglehart claims that today’s adolescents are more focused on non-materialistic values such as creativity, self-development and the environment than earlier generations. The results above support this, but traditional values, such as earning money and safe jobs, are also important for the students.

Girls are an important target group for recruitment to STEM, as they make up a relatively small proportion of today’s STEM population. Recruitment efforts should speak to the girls’ interests and concerns as much as to boys’ interests and values. Efforts directed at girls should show them that they can do something meaningful and idealistic through a career in

STEM fields. Girls' self confidence in STEM subjects are lower than boys', and this might be an important factor keeping girls out of science and technology subjects. Therefore it could be fruitful to develop more long-term initatives aimed at enhancing girl's expectation of success.

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INQUIRY AND LEARNING IN SCIENCE: A STUDY OF REMEMBERING AND GOALS IN A CLASSROOM

Annie-Maj Johansson

Dept. of Mathematics and Science education
Stockholm University and School of Health and Social Sciences University of Dalarna

ajn@du.se

Per-Olof Wickman

Dept. of Mathematics and Science education
Stockholm University

per-olof.wickman@mnd.su.se

ABSTRACT

In science education scientific concepts and phenomena are introduced that can be difficult for students to understand or talk about. In this study the ultimate learning goal about how friction facilitates or restricts movement is introduced by the teacher through more proximate goals. We have studied two such proximate goals used by the teacher: 1) why cars have tyres and 2) that a vehicle can continue to travel indefinitely if there is no resistance at all. The events in the classroom were filmed and transcribed and as a method for analysis practical epistemology analysis (PEA) was used. The study shows how both the students and the teacher mainly remember experiences on the basis of the more proximate goals rather than from more ultimate scientific learning goals. Further there is no continuity created through teaching that aid remembering in a way that explicitly connect the more proximate goals to each other or to the more ultimate scientific goal. We discuss how teachers' may create continuity between these different goals.

Keywords: *inquiry, science, learning, continuity*

INTRODUCTION

One important task for science education is to introduce new scientific concepts and make their relationship to observable phenomena evident, e.g. understanding how friction affects movement. As such a goal is rather difficult for students to understand and to talk about before the concepts are fully comprehended (which is the goal), it is usual that the dialogue in the classroom starts from more proximate goals (*ends in view* in Dewey's parlance), e.g. why cars have tyres. These proximate goals make sense to the students by giving them a goal to which they can relate their experiences of phenomena, although they could still find it difficult to connect the proximate goals to the scientific ultimate learning goal. According to Dewey (1938/1997) it is the ends in view that became crucial for the students' progression of learning, rather than the ultimate scientific ends. Therefore it is crucial how proximate and ultimate goals can be given continuity together with the students in their activities. In this study we compare proximate and ultimate goals and the extent to which they connect to each other through what is remembered during class based on the proximate and ultimate goals. Many researchers have studied conceptual understanding (e.g. Osborn,1984; Duit & Treagust, 2003; Novak, 1998), whereas other researcher have studied the role of context, for what students remember, and thus can learn (e.g. Säljö and Wyndhamn,1993; Schoultz, Säljö and Wyndhamn, 2001). Here we bridge these studies by examining how continuity between proximate and ultimate goals is needed in helping students to remember relevant events based on the proximate goals.

METHOD AND ANALYSIS

This study considers teaching movement and friction in physics through an inquiry-based approach. Movement and friction is a standard unit for late elementary school in Sweden. The study describes a discussion between a Year 5 school class and their teacher. The starting point is an inquiry by the students on how the movements of a toy vehicle change when it is rebuilt so that the friction increases or decreases. Focus is on two proximate goals, why cars have tyres and if a vehicle can continue to travel indefinitely if there is no resistance at all. Both of these goals are subordinated an ultimate goal that the students should learn about how friction facilitates or restricts movement. The events that took place in the classroom were recorded with two video cameras and have been transcribed. Like Wickman and Östman (2002) we in this analysis coded utterances by the teacher and the students in order to see how they where related to proximate and ultimate goals and how they where made continuous through using certain words and the experiences related to.

RESULTS

The classroom discussion takes its starting point from the experiments, and the discussions dealt with what the student and teacher remembered as relevant events and observations and ways to talk based on the goals. We have studied two situations which followed upon each other the same afternoon. First they treated proximate goal 1, why the students thought cars have tyres, and second proximate goal 2, if a vehicle can continue to travel indefinitely if there is no resistance at all. In treating goal 1, the students' experiences are made salient and they have ample opportunity to use their everyday language in a direct and understandable way. The study shows that the conversation mainly serves the proximate goal of discussing why cars have tyres from two perspectives, first because they make it possible for the car to move ("we wouldn't get anywhere"), and because without them the rim or the roads would be broken ("there would be big holes in the road"). In this discussion the proximate goal is not related to the ultimate one. In the discussion dealing with proximate goal 2, instead the teacher's experience is of central importance. This is evident from teacher statements like "if there wasn't any resistance at all, air resistance like you have felt with the car and no resistance on the road or in any of these parts, then these vehicles, when they are pushed, would continue indefinitely". The students' experiences mainly serve as counterexamples to the teacher's statement. Students for instance object "What if it is an uphill, then?". The study also shows that the conversation mainly serves the proximate goal of discussing if a vehicle can continue to travel indefinitely if there is no resistance at all. The proximate goal is not related to the ultimate scientific goal, which is evident in that the students' and teacher's experiences and use of language do not refer to the ultimate goal of friction facilitating or restricting movement. Again there is a lack of continuity of explicitly discussing the relation between the more proximate and ultimate goals.

CONCLUSIONS

The conversations in the study mainly serve the proximate goal, whereas the ultimate scientific goal does not become known to the students. There is also a lack of continuity of explicitly relating the more proximate goals to each other and to the more ultimate scientific goal. The study also shows that an important part of teaching involves helping the participants to remember relevant events based on the proximate and ultimate goals and how this influences what the students are offered in terms of learning. This highlights the importance of teachers to continually help students create relation between the different goals. We argue that this is one of the teachers' most important tasks.

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SOCIO-CULTURAL AND HUMAN VALUES IN TEACHING & LEADERSHIP

Firouzeh Kamal
Isalmic Azad University
Tehran Brach of Science and Research
Department of Educational Administration
firouzeh47@hotmail.com

Amir Razjoo
Islamic Azad University
Tehran Branch of Science and Research
Department of Educational Administration
amir_razjoo@yahoo.com

Mohammad Reza Behrangi
IOSTE Regional Representative for Countries around Persian Gulf.
Islamic Azad University
Tehran of Science and Research
behrangimr@yahoo.com

ABSTRACT

Believing that a positive change in teaching will result in positive changes in socio-cultural and human values, therefore it will make educational administrators responsible to supervise teachers toward effective use of teaching methods. This article encourages more student-centered teaching and shows how it is used in a course of supervision in educational administration at the graduate level for understanding the concepts of one chapter "Teaching & Leadership" in one session in a way that instructional and nurturing effects on students' socio-cultural & human values will be considered. Data gathered and analyzed statistically through using 72 Behrangi's indicators of effective instruction.

Keywords: *instructional impact, values in teaching leadership, graduate course of supervision.*

INTRODUCTION

Shouldn't it be the main goal of each education to create and improve human values and ethics in students? What would be the use of science in improving quality of life if love and respect, peace or trust is not used in teaching?

Today's education needs to be moved away from the 'chalk and talk' philosophy of previous generations. Educational administration should take into account socio-cultural and human values in teaching/learning process.

Students come from different family backgrounds, economical situations and cultural levels. It's vital for every teacher to know these diversities so that he/she can interact properly with each student. An effective approach to learning leads to quality learning outcomes. While teaching and learning should be inseparable, the teacher conducts the learning process. Therefore, the teacher should use appropriate teaching strategies to encourage students to use deep level approaches to learning. This article discusses how effective learning will have positive impact on socio-cultural and human values including students' self esteem, ability, achievement, knowledge, eagerness to learn, creativity, attitude, awareness, bravery, communication, competition, cooperation, confidence, control, curiosity, independency, emotion...

A brief explanation on the stages of our scenario for teaching one chapter of supervision course "Professional Knowledge about Teaching & Leadership" will make our intention more clear:

The actual teaching starts with a question, one which draws all attention to a specific subject which is the main concern of that session's teaching. There are also pictures conveying the same meaning all around the class. One of the two instructors, then, illustrates the chapter's map so that every student will get a general picture of what he will go through by the end of the class. The instructor also gives a general explanation on the subject and the methods she chooses to teach each part of the map. A scenario was designed using "Instructional Variables" and the steps of using role playing model of teaching with the help of another instructor.

During the play all students are required to pay extra attention to the subjects and write down the key words/phrases. After the play each student is requested to consult the result of his/her understanding with the student sitting next to him/her. Then they will consult it in groups of 3-5 depending on the total class population. Now a representative of each group comes to the front of the class to write down his/her group's findings. Each group representative also explains what he/she understands from the play. Students will discuss important issues together and clarifications will be made if required by the teacher.

Now another instructor starts another section of the map "Variables of Classroom Teaching", he has prepared flashcards including main explanation on each topic; he has also made a picture conveying the concept he is going to transfer. Dividing the class into groups of 3-5, the instructor gives each group some pictures along with some flashcards, he then asks them to find the suitable picture for each flashcard. Each group's representative then comes to the whiteboard to attach the pictures and related flashcards to the board and explains what he/she understands. Students will discuss important issues concerning the subject and the instructor will guide them in the right direction if required. In each part of the training/learning process socio-cultural and human values were getting into practice. We worked on students' dignity, creativity, self-esteem, confidence, memory, cooperation, fears, feelings, forgetfulness, freedom, growth, hope, intelligence and many other aspects altogether.

METHODS

At the end of the session a 45 item questionnaire on the basis of Behrangi's accredited questionnaire containing 72 evaluation indicators distributed among 27 students asking them to compare the present teaching method with the traditional methods in order to understand the impact of each method on socio-cultural and human values. The data has been analyzed using Veil nonparametric and Wilcoxon Ranks Test and we achieve the following results.

RESULTS

NPar Tests-Descriptive Statistics
Table 1

	N	Mean	Std. Deviation	Minimum	Maximum
sumscorerppw	27	204.44	12.786	170	221
sumscorelecture	27	67.41	17.485	30	116

Wilcoxon Signed Ranks Test
Ranks
Table 2

	N	Mean Rank	Sum of Ranks
Negative Ranks	27(a)	14.00	378.00
Positive Ranks	0(b)	.00	.00
Ties	0(c)		
Total	27		

a sumscorelecture < sumscorerppw
b sumscorelecture > sumscorerppw
c sumscorelecture = sumscorerppw

Test Statistics(b)
Table 3

	sumscorelecture - sumscorerppw
Z	-4.543(a)
Asymp. Sig. (2-tailed)	.000

a Based on positive ranks.
b Wilcoxon Signed Ranks Test

CONCLUSIONS

Considering the sequential data for each sample, the total score for each teaching method was calculated then through using veil dependant nonparametric test and Wilcoxon signed Ranks Test with 99 percent assurance level, z was calculated as 4.543 which shows there is a meaningful difference between two methods of teaching and that students gain much more on socio-cultural and human values through role playing & picture-concept models of teaching.

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A SURVEY ON TURKISH PRE-SERVICE SCIENCE TEACHERS MOTIVATION TOWARD THE ENVIRONMENT

Güliz Karaarslan

Department of Elementary Education
Middle East Techinical University
Ankara/Turkey

kguliz@metu.edu.tr

Hamide Ertepınar

Department of Elementary Education
Middle East Techinical University
Ankara/Turkey

hamide@metu.edu.tr

Semra Sungur

Department of Elementary Education
Middle East Techinical University
Ankara/Turkey

ssungur@metu.edu.tr

ABSTRACT

The purpose of this study was to determine Turkish pre-service science teachers' motivation toward environment. The data were obtained through Turkish version of Motivation toward Environment Scale (MTES). A total of 134 pre-service science teachers participated in the study. Descriptive results of the MTES revealed that the highest mean score was obtained on identified regulation sub-scale. This finding suggested that Turkish pre-service science teachers tend to do pro-environmental behaviors for mainly personal reasons. However, the lowest mean score on the external regulation implied that Turkish pre-service science teachers are less likely to show environmental behaviors for extrinsic reasons.

Keywords: *Motivation toward environment, self determination theory, pre-service science teachers*

BACKGROUND, FRAMEWORK AND PURPOSE

Many theoretical frameworks have been developed to explain the discrepancies among people's environmental knowledge, environmental awareness and pro-environmental behaviors. However, no definite explanations have been developed (Kollymus & Agyeman, 2002). While some studies revealed a significant relationship between environmental attitudes and behaviour (Arbuthnot,1977), there are studies demonstrating that there is no relationship between environmental attitude and behavior (Gill, Crosby, & Taylor, 1986). Even if people claim to have pro-environmental attitudes, they rarely act in terms of those attitudes (Pelletier, Tuson, Green-Demers, Noels and Beaton, 1998). Therefore, it is suggested that individuals should have a drive toward behaviour change for environmental issues. Self determined theory (SDT) is a theory which emphasizes this drive and environmental motivation. According to the theory**,** people who have self determined motivation toward environment sustain the behaviors in a long term basis while people externally reinforced quits the behavior when external force is absent for a long time (Pelletier, 2002). This theory was supported in many different domains. In the environmental domain, an instrument namely Motivation toward Environment Scale (MTES) was developed by Pelletier, et.al (1998) to asses individuals' motivation toward environment based on the SDT. The purpose of this study is to determine Turkish pre-service science teachers' motivation toward environment using the MTES.

METHODS

In this study, Turkish version of the MTES was used to assess Turkish pre-service science teachers' motivation toward environment. During its validation for Turkish sample, the MTES was administered to 134 pre-service science teachers in two large public universities located in Ankara, Turkey. The scale consists of 27 items in 6 subscales: intrinsic motivation, identified regulation, integrated regulation, introjected regulation, external regulation and amotivation. In order to validate the six-factor structure, confirmatory factor analyses (CFA) were conducted and croanbach's alpha coefficients were calculated as measures of reliability. Then, Turkish pre-service science teachers' motivation toward environment was examined through descriptive statistics.

RESULTS

The CFA results showed that, Turkish version of the MTES has six-factor structure. Each factor had satisfactory internal consistency. The overall reliability of the scale was calculated as 0.82. The mean score on the whole instrument was 4.51 with a standard deviation of 0.64. Examination of the mean scores for each sub-scale revealed that students exhibit environmental behaviors for different reasons. The highest mean score on identified regulation sub-scale (M=6.06) demonstrated that Turkish pre-service science teachers tend to do such behaviors for mainly personal reasons. However, the lowest mean score on the external regulation (M=2.18) implied that Turkish pre-service science teachers are less likely to show environmental behaviors for extrinsic reasons such as obtaining rewards.

Table 1. Means and Standard Deviations of the MTES Subscales

	M	SD
Intrinsic motivation	5.40	1.17
Integrated regulation	5.30	1.20
Identified regulation	6.06	0.96
Introjected regulation	5.46	1.21
External regulation	2.18	1.30
Amotivation	2.32	1.14

CONCLUSION AND IMPLICATIONS

SDT has some important implications for environmental education. It may help better understanding of individuals' autonomous motives for participating in environmental behaviors. Also, SDT may be critical to develop effective environmental education programs and to create pro-environmentalists or activists who could take important steps for the protection of environment (Pelletier, 2002). Moreover, the development of MTES based on the SDT and adaptation of it into different languages may contribute to in-depth investigation of the interaction between environmental behaviors and motivation and to integration of the environmentally responsible behaviors into people' lifestyle (Pelletier, et.al, 1998). In the light of all these issues, to grow individuals who have more self determined motivation toward environment, SDT guided environmental courses may be integrated to teacher training programs.

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EXPERIENCING LEARNING SUPERVISION SCIENCE THROUGH ATYPICAL USE OF ECLECTIC MODEL OF TEACHING FOCUSING SOCIO-CULTURAL AND HUMAN VALUES EFFECTS

Nazila Karimi

Islamic Azad University

kariminazila@yahoo.com

Mohammadreza Behrangi

Tarbiat Moallem University
Regional Office of IOSTE in Persian Gulf Countries

behrangimr@yahoo.com

ABSTRACT

Demonstrating how new teaching approach (eclectic model) in teaching supervisory science would lead to enhance instructional effects and nurturing socio-cultural and human values of learners to live with in the contemporary global society. The research is a semi-experimental case-study. The researchers made 65 items questionnaire administered to a sample size of 51 randomly selected students from School of Educational Administration in Islamic Azad University of Science&Research**.** Data was analyzed to compare the effects of lecture method with eclectic model. Findings show the significant effect of eclectic model and allow recommending the use of it in teaching other chapters and courses.

Keywords: *eclectic model of teaching, supervision, nurturing effects, lecture method.*

INTRODUCTION

Findings from many investigations on the quality of education in the whole world indicate the schools have disruptive effects on learners' innate capabilities and understandings. It seems to be a revolutionary work to teach in atypical trend and bypass the inertia of existing educational administration to orient teaching for learners understanding of socio-cultural and human values. In this study main concepts of educational supervision such as supervisors' characteristics, supervision definitions, key concepts, incremental expansion of the role, different components in supervision, and new technology will be considered (Wiles & Bondi, 2004). The critical concepts are taught in two different ways, lecture method and eclectic model of teaching. The eclectic approach combines concept attainment and inductive models of teaching for affecting cognitive information processing. It also uses role playing, and jurisprudential inquiry models of teaching for nurturing effects. The article indicates one sample of bit after bit endeavor of serial cases on using the approach in teaching chapters in supervision course. The researchers made 65 items questionnaire by Likert scale with five degree of agreement (1 to 5), investigates the view of the graduate students attending the course of supervision. Sample size is 51 randomly selected (Krejcie & Morgan's table (1970) & Yamane formula (1967))students of educational administration of Management and Economic School in Islamic Azad University of Science and Research with 32 female (62.7 %) and 19 male (37.3 %). Findings are classified into two categories of instructional and nurturing effects. The nurturing effects embodies items such as personal integrity, comfort in expressing opinions, skills in negotiation, enhancing empathy and pluralism, finding facts about social problems, capacity for social involvement and desire for social action, self-esteem, academic and social motivation, learning capacity, ability to assume role of the "others" competence in social dialogue and achievement. The instructional effects embodies items such as: self-understanding and reflection, self-development of concepts, framework use for analyzing social issues, effective group process and governance, constructivist view of knowledge and discipline of collaborative inquiry, learning with the process of problem solving and inquiry, making hypotheses and definitions of concepts (Joyce, Weil & Calhoun, 2009).

METHOD

Determining reliability of questionnaire after a pilot study with 15 students, shows reliability of questionnaire: Cronbach's Alpha for Inductive (item1-12) =0.885, Attaining concepts (item13-26) =0.899 Advance organizer (item 27-41) =0.928, Role playing (item42-52) = 0.911, jurisprudential inquiry (item53-65) = 0.927, lecture method (item1-65) = 0.947, Eclectic model (item1-65) = 0.958.

Regarding hypothesis 1, finding shows (**Table 1**) that with 99% of confidence level the differences between scores of eclectic model and lecture method are significant, so null hypothesis 1 is rejected:

Table 1. Descriptive Statistics & Wilcoxon Signed Ranks Test for instructional and nurturing effects

Scores	N	Mean	Minimum	Maximum	Wilcoxon Signed Ranks Test
Sum score eclectic. m (Instructional effect)	51	134.27	98	155	Z= -6.188 (a)
Sum score lecture. m (Instructional effect)	51	68.08	38	155	Asymp. Sig. (2-tailed)= .000
Sum score eclectic .m (nurturing effect)	51	150.71	100	170	Z= -6.215 (a)
Sum score eclectic .m (nurturing effect)	51	61.47	33	147	Asymp. Sig. (2-tailed)= .000
Sum score eclectic. m hole effect	51	284.98	198	325	Z= -6.215 (a)
Sum score lecture. m hole effect	51	123.82	70	287	Asymp. Sig. (2-tailed)= .000
(a) sum score lecture method < sum score eclectic model					

Hypothesis 2: There is no significant difference between instructional and nurturing effects of five models of teaching. Finding shows (**Table 2**) that with 99% of confidence level, the differences between scores of five model of teaching method is significant so hypothesis 2 is rejected:

Table 2. Instructional and nurturing effect of five model of teaching (Friedman test)

Models - scores	Mean Rank instructional effect	Mean Rank nurturing effect	Mean Rank instructional & nurturing effect
inductive model	3.02	2.05	2.10
attaining concept	4.82	1.01	3.81
Advance organizer	4.14	2.98	4.89
role playing	1.00	4.57	1.20
Jurisprudential inquiry	2.02	4.39	3.00
N	51	51	51
Chi-Square	196.205	192.579	171.204
Df	4	4	4
Asymp. Sig. (2-tailed)	.000	.000	.000

RESULTS & CONCLUSION

Findings indicate that, with 99 % of confidence level both eclectic model and five models of teaching have significant instructional and nurturing effects on students' learning in comparison with lecture method. Results of two hypothesis of study shows that the attaining concepts & constructive models have more instructional effect and role playing & Jurisprudential inquiry model have more nurturing effect in teaching the supervision concepts, therefore their use have priority and are highly recommended. Nurturing effect is related to socio- cultural and human values. As the findings of study showed, eclectic model of teaching can enhance these effects on students. There are many models such as simulations, picture words, indirect method, and partner in learning (Joyce, Weil & Calhoun, 2009) which are useful and effective for teaching concepts of academic courses. There are still needs to investigate the instructional and nurturing effects of these models of teaching and compare the results with their instructional & nurturing effects on students with lecture methods.

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THE IMPACT OF USING VIDEO TECHNOLOGY ON THE DEVELOPMENT OF STUDENTS' META-COGNITIVE STRATEGIES: A NEW USAGE OF MODERN DIGITAL LITERACY TECHNOLOGIES IN THE STATE UNIVERSITY OF ISFAHAN

Karimi Vajiheh

Educational Administration Department,
School of Psychology and Education
Tarbiat Moallem and Payame Noor University

vajiheh_karimi59@yahoo.com

Behrangi Mohamadreza

Educational Administration Department,
School of Psychology and Education
Tarbiat Moallem University

behrangimr@yahoo.com

ABSTRACT

This study investigates the impact of video technology on the development of selected students' meta-cognitive strategies Isfahan University in Iran. 310 students from the whole 1600 were selected based on cluster random sampling. The samples of students of experimental and control groups were selected from all of the University of B.A. 155 of them had access to video technology for English language teaching and the other 155 did not. The data were collected based on a researcher made questionnaire. An independent t-test was employed to compare these two groups. The results indicate that although using technology enhances the students' meta-cognitive strategies it does not have the same effect regarding planning, control and supervision, constructing order.

Key word: *digital literacy, technology, video technology, meta-cognitive strategy*

INTRODUCTION AND LITRATURE:

In education's field, using modern technology should be a means toward improving learning and education. As Behrangi (2005) indicates regarding digital and up to date sources in the development of learning and new literacy, this technology has important role at the present time provided that it's suitable use and its flexibility in using time, place, age, acceptance and fitness with the new jobs to be considered. He also reiterates that this century students' interactions and involvements have been extended and overcome the classroom constrains of data gathering through the use of suitable computers programs, electronic networks, and audio-visual media. This study focuses on meta-cognitive strategies and video technology as a type of new digital literacy.

Learning skills are divided in two parts, cognitive and meta-cognitive. These idioms complete each other. Cognitive skill us point to the process that we can learn, think and remember. Meta-cognitive refer to our knowledge about our meta-cognitive process and more using of them to reach to purposes of learning (seif, 2006). Meta-cognitive is defined as knowledge and awareness about our cognitive system or knowledge about knowing. The ones` awareness about itself, he or she makes able to supervise and direct her/his suitable thoughts (Ahadian quoted from Anderson, 2009). By the use of Meta cognitive, a person is capable to, manage and lead his/her learning. Meta cognitive involves three types of important information: the knowledge that is related to the individual interests, preferences, and general awareness and knowledge on his/her learning, the information that related to the difficultly of the task, and knowledge on learning strategies techniques such as precise reciting in reading. The person's knowledge on his information, help him/her to use them in three meta- cognitive strategies (Afzalnia, 2006). The first strategy is programming strategy, learner is capable to plan through determining goal, predicting the time of study and setting the speed of study. The second strategy is Control and supervision strategy that in improvement of the process is leaded by the person through formative evaluation procedure. Purpose of control and supervision strategy is learners' measurement of his/her work and recognition of the way of progress and directing it. Final strategy is Constructing order strategy: Tthis strategy make more flexibility in behavior learner and helps him to change his method and style of learning any time that is necessary. The constructing order and supervision strategies are applying in a harmonic way (Afzalnia, 2006).

METHODS

This effect is kind of half-empirical research. In this study, the abilities of students meta-cognitive are measured in two groups: Experiment group and control group. In experimental group, in addition to the usual methods what were applying in control group, also video technique is used. The information about students' meta-cognitive skills in both groups is collected by applying a questionnaire (45 questions) of researcher-made that the reliability coefficient of this is 0/824. An independent t-test was employed to compare these two groups in three strategies.

RESULTS

Findings indicate that based on obtained results by counted T is bigger than critical amount of table in 0/01 and 0/05 level. There for, the first assumption of test (based on using video technology in training language results in development of students programming strategy) is supporting. So using this instrument helps learners for making purposes for learning, forecasting of necessary time to study and setting the speed of study. Based on obtained results by counted T is bigger than critical amount of table in 0/01 level. So, the second assumption of test (based on using video technology in training language results in development of students' control and supervision strategy) is accepted. This strategy causes that learner repair or change in time. Also, this strategy makes him able to increase attention and focus during a study. In the end, based on obtained results by counted T is bigger than critical amount of table in 0/01 and 0/05 level. So, the second assumption of test (based on using video technology in training language results in development of students' control and supervision strategy) is accepted. This strategy causes flexibility in learners' behavior and helps him to change his method and style every time that is necessary.

CONCLUSIONS:

The data in this study reminder that The programming and constructing order strategies are using video technology method more than control and supervision strategies strategy. The reason can be expressed by this way that, using this method in class and training situation make it possible to access to high level cognitive purposes i.e. (analyzing and evaluated). So learner will be able to direct their study, memorize and remember their information and arrange them. Also if there will be any problem in learning, defect point will be recognized immediately and will be diagnosed that the problem is coming from themselves subject or training method. Thus they can have an exact constructing order and programming on their learning. Science by considering the results can be suggested to people who are responsible in training that compiling educational lessons in textbooks should be proper with students' ability, put meta-cognitive strategies as a part of educational program and make possible using modern learning equipment in schools and universities. Also suitable educations in order to develop human forces should be done to becoming familiar with meta-cognitive strategies, helpful instrument for training and how to use them in class situation.

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INDIVIDUALIZED AND INTEGRATED ELEMENTARY SCIENCE INSTRUCTION

Sibel Kaya
Kocaeli University
sibelkaya@gmail.com

Carol McDonald Connor
Florida State University
cconnor@fcrr.org

Melissa Luck
Florida State University
melissa-luck@hotmail.com

Phyllis S. Underwood
Florida State University
punderwood@fcrr.org

Novell Tani
Florida State University
ntani@fcrr.org

Diana Rice
Florida State University
drice@fsu.edu

Angela Canto
Florida State University
acanto@fsu.edu

ABSTRACT

Although some early elementary teachers may hesitate to teach science, either because they do not feel qualified or because they feel that reading and math take priority (Marx & Harris, 2006), schools and teachers are becoming increasingly accountable for their students' science learning. By using the Bybee's (1997) 5-E Learning Cycle as a framework, a second grade science curriculum was designed to individualize student instruction (ISI-Science). The study employed both science process and literacy skills through hands-on activities and the use of text. Results showed that students' science and literacy scores improved at the end of individualized and integrated science and literacy instruction regardless of their initial science knowledge.

Keywords: *5-E learning cycle, elementary science, individualizing student instruction*

INTRODUCTION

In recent years, influential policy reports (National Academy of Sciences, 2006; National Science Board, 2007; U.S. Department of Education, 2000) emphasize the need for equal time for science, mathematics, and language arts teaching. However, in national comparisons, teachers reported spending consistently less time in science instruction compared to language arts and mathematics (Center on Education Policy, 2007; Fulp, 2002; Weiss & Pasley, 2004). With the demands of the *No Child Left Behind Act* and the increasing emphasis on students' reading performance, teachers may believe that time spent on science impedes students' reading development and, therefore they devote less time to science instruction compared to language arts and mathematics (Marx & Harris, 2006). Teachers also may not be provided with adequate science background knowledge and support to feel comfortable teaching the subject (Fulp, 2002; Weiss, Banilower, McMahon, & Smith, 2001).

National Science Standards state that students should be able to learn science concepts and processes more effectively when they engage in meaningful activities through manipulating materials (National Research Council, 1996). When hands-on activities are integrated with concept-focused teaching, reading of science print materials, and writing, both science understanding and reading achievement may be improved (French, 2004; Romance & Vitale, 2001). The purpose of this study here was to develop and assess the efficacy of a second-grade science curriculum that integrated science and literacy learning objectives with the goal that students would improve both their science content knowledge and their overall literacy skills.

Research Questions: 1. Did students' knowledge of science content improve from pretest to posttest? 2. Did students retain Unit 1 knowledge as assessed by multiple choice and open-ended items? 3. Were students who showed the lowest level of science knowledge on the pretest able to make the same gains in target content knowledge as students with higher pretest scores?

METHODS

The study included 6 second-grade classrooms, located in a mid-size South-Eastern City in the U.S. 96 children participated in this study (45 girls, 51 boys). About 50% of students were living in high poverty homes. More than 50% were African American, 40% White, and the remaining consisted of other ethnic groups. Classroom teachers (6) and research-funded teachers (3) were all fully certified to teach in elementary schools.

Two science units that were tailored toward individual students' needs and integrated with literacy were developed. The two units spanned throughout six months with each lesson lasting 30-40 mins. Research-funded teachers taught the first lesson in all classrooms while the classroom teacher observed and assisted. Responsibility for teaching subsequent lessons alternated between research-funded teachers and classroom teachers. To structure the lessons within the unit, the 5-E Learning Cycle (Bybee, 1997) was used. Each lesson included activities where students engage in hands-on/minds-on learning, discussion, reading, and writing. S*trategic flexible grouping of students*, individualized reading materials and worksheets were utilized. Student learning was assessed by a science knowledge unit test, in addition to standardized tests, completed the week prior and the week following the six-week unit. Unit tests were designed by the researchers to assess student science learning in areas of instruction (i.e., target content) as well as in related areas that were not directly taught (i.e., nontarget content). Both tests generated an α reliability coefficient of 0.90. Series of paired sample *t*-tests with Bonferroni correction were conducted to determine if the average gains made from pre- to post-tests were statistically significant. Independent *t*-tests were conducted to determine the differences in the gains of students with the low and high levels of science knowledge.

RESULTS AND CONCLUSION

Students' science and literacy scores significantly improved at the end of individualized and integrated science and literacy instruction. Regardless of students' science pretest score (lower or higher), on average, they made the same gains. Students retained Unit 1 knowledge even after four months of its implementation. Students generally showed greater gains on the science topics that were explicitly taught during the unit than on related topics that were not explicitly taught.

Teachers were able to implement the science curriculum and contribute important ideas and extensions so that it worked better in the classroom. Individualizing instruction in science benefited students with weak science and literacy skills as well as students with strong science and literacy skills. This study did not intend to show that ISI-Science curriculum was more effective than other curricula or using other strategies; we compared only the pretest and posttest scores of students who received the curriculum. For future research, we plan to compare the ISI-Science curriculum to the core science curriculum used in the schools by randomly assigning teachers to teach science using either ISI-Science or the school curriculum. Nevertheless, our results so far are encouraging.

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INDIGENOUS KNOWLEDGE SYSTEMS: PROCESS VS PRODUCT

Moyra Keane

University of the Witwatersrand,
Johannesburg, South Africa

moyra.keane@wits.ac.za

ABSTRACT

This paper draws on research into Indigenous Knowledge (IK) in science education with both rural and urban communities in South Africa. I present findings on a) drivers for work in IK; b) Educators' perceptions of IK; c) examples of the value of process over product. In the light of new education policies, teachers are grappling with questions such as: 'What is IK?' 'What is the value of it?' 'Does "it" belong in the science curriculum?' Yet, perhaps we should be discussing 'What processes lead us to knowing?' 'What are the features and value of this intellectual journey?'

Keywords: *Indigenous Knowledge, science curriculum, epistemology.*

INTRODUCTION

Outcomes, products, results easily draw attention and claim significance. A product is generally more definable and quantifiable then a process. It is hence easy to miss the value of process. In integrating IK into the learning and teaching of science, it is the opportunities for discussions, for reflection, for the problematising of troublesome knowledge, in the struggle to reconcile conflicting perspectives, that rigour in the intellectual endeavour is nurtured. This paper therefore focuses not on Indigenous Knowledge as a product to be included in science learning but on the opportunities provided by considering our motives for engaging in the debate, concerns around the intersections of science and IK, and perceptions of valid knowledge.

Two research projects, one in urban schools and one in a rural community indicated that drawing examples of IK into science lessons increased interest and created relevance for students. This was also the finding of Manzini, (2000) and Malcolm, (2004) who worked in similar communities. However, finding examples of relevant IK remains elusive in many settings and for many teachers. This difficulty often deters teachers from considering IK as an aspect of the science classroom – in spite of this being Education Department policy.

DRIVERS FOR WORK IN INDIGENOUS KNOWELDGE: PROCESS vs PRODUCT

The reasons for the rise in interest in promoting IK are generally well accepted. I summarise these briefly. One of the drivers is redress. Indigenous ways of knowing have been excluded from school and university curricula for decades and IK has often been denigrated, where it has a valuable contribution to make on a variety of levels (Emeagwali, 2003). In national efforts towards transformation, inclusion and social justice, multiculturalism, and multilingualism are being promoted. The second reason for seeking to include IK into curricula is the belief that contextualised learning and learner-centred approaches promote epistemological access and enhanced concept development. A third reason is the intrinsic value of IK which may for example contribute to global solutions to environmental problems.

A fourth reason for more general interest in IK is the potential commercial benefits – for example in ethnobotany. At the policy level there is some agreement with the arguments presented here. Difficulties arise however for science educators in South African schools as they try to determine exactly what IK is appropriate for inclusion into science classrooms.

METHODS

Data for the arguments presented here have been drawn from aspects of two studies as well as a seminar series for academics working in IK. One study in rural schools explored teachers' and community's ideas about relevant science (which included IK); the second study, in a cluster of urban schools, sought teachers' perceptions of IK and their willingness to include it in their science teaching. The seminar series took the form of debates, reflective writing, stories, and research experiences in IK. I have drawn out common features from these projects to argue for the value of the inclusion of IK into science curricula.

RESULTS

Teachers and/or community elders in our projects defined various categories of IK: hidden knowledge for specific groups (mostly relating to roles in the community); myths, superstitions and spells; basic technology; ways of living in nature and ways of seeing the world. Finding examples from these categories that may be included in science curriculum proved difficult. Participants agreed that these categories overlap and are possibly inseparable. Many students' and teachers' experiences of IK include religious and supernatural aspects which they are reluctant to bring into the classroom.

CONCLUSIONS

It is the process of wrestling with this difficult conundrum that the fifth driver for the interest in IK emerges. This is the contribution IK can make to freeing us to some extent from fixed paradigms and habitual ways of seeing and being in the world. In this last driver for promoting IK we find some consonance with scientific and intellectual endeavours. I am not arguing to negate other reasons for the promotion of IK in science curricula, but by acknowledging the value in the very process of investigating knowledge claims and status we are able to become more reflective thinkers, more tolerant human beings, and are also able to reconcile some of the paradoxes and difficulties in determining *what* IK to include in science teaching.

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SLOWMATION: HELPING PRESERVICE TEACHERS DEVELOP PEDAGOGICAL KNOWLEDGE

Stephen Keast

Monash University

Keasty@education.monash.edu.au

Rebecca Cooper

Monash University

Rebecca.Cooper@education.monash.edu.au

Gary Hoban

University Of Wollongong

ghoban@uow.edu.au

ABSTRACT

This study investigated the use of Slowmation to assist preservice teachers to discuss issues of teaching and student learning and reflect on their developing pedagogical knowledge. After being introduced to Slowmation at university and making their own movies, the preservice teachers taught science in secondary schools using the procedure during their teaching placement. After placement, when the preservice teachers returned to university classes they were required to show their completed students' movies to the class. These presentations were conducted in a way that allowed the preservice teacher presenting the movies to be in control of the class and the discussion. This instigated rich conversations about teaching, learning and understanding of pedagogy between the preservice teachers. The authors assert that Slowmation is an effective teaching procedure to engage preservice teachers in rich conversations that build on their shared experience to review and reflect on their teaching. Such rich conversations assist preservice teachers to assimilate their developing understanding of teaching and learning into a coherent model of pedagogical knowledge.

Keywords: *Science Teacher Education, Technology, Developing Pedagogical Understanding.*

INTRODUCTION

This paper is based on the work of the authors as they teach in the science curriculum unit of the final year of the teacher education program at Monash University in Clayton, Australia. Slowmation is a Teaching Procedure (Mitchell, 2009) where students design and create short movies of their understanding or science concepts. Students make models of scientific concepts, take digital still images of the models and join them to make short 2 – 3 minute movies. This paper offers a further investigation (Keast, Cooper, Berry, Loughran, & Hoban, 2009) in addressing the problem, "How do preservice teachers synthesise the elements of learning about teaching into a coherent model of pedagogical knowledge?" Slowmation is being used by the teacher educators at Monash University in a way that encourages pre-service secondary teachers to make public their developing understanding of their personal pedagogical knowledge (Morine-Dershimer & Kent, 1999). This gives teacher educators an insight into how preservice teachers are forming their conceptions and understanding of personal pedagogical knowledge.

METHODS

Like Nicaise and Crane (1999), this Slowmation research design used a qualitative and descriptive approach drawing together data from multiple sources: preservice teachers' presentations of their students' Slowmation movies; lecturers' field notes from presentation sessions; journals kept by the lecturers; and, the lecturers' guided reflections on each other's journals. Such a research design then led to a grounded theory framework for analysis such that knowledge was built-up from the complex description of the classroom (Nicaise & Crane, 1999) and lecturer-student, student-lecturer, lecturer-lecturer and student-student interactions. During their 5 week placement preservice teacher were asked to teach Slowmation to their students during practicum and to show their students' completed movies to their General Science peers on their return to the university.

RESULTS

Due to space limitations in this short paper, the authors use one example of two pre-service teacher's reflection on their teaching, though in the full paper several issues will be analysed and discussed. The preservice teachers agreed that the process of Slowmation was useful for helping them to identify students' alternative conceptions of a science concept. One preservice teacher commented:

The major conception they had before they started, was they had the light and dark reactions mixed up [in photosynthesis], and didn't show how the process worked, ... the Slowmation did reveal to me areas that students didn't fully understand and where I needed to re-teach the ideas. (PST1, Classroom presentation, 2007)

The student's work on their Slowmation movies gave the preservice teachers opportunities in which they could 'see' their students' understanding and could monitor their learning. They were able to identify their students' alternative conceptions. The discussion of slowmation gave preservice teachers an opportunity to explore their personal practical experience (Morine-Dershimer & Kent, 1999) and reflect on the implications of when to teach in the unit (an example of personal pedagogical knowledge, Morine-Dershimer & Kent, 1999). Working with science concepts at a technical level (in terms of Slowmation as a teaching procedure) introduced preservice teachers to new understandings of the complexity of some abstract science concepts.

CONCLUSIONS

Finally, what has been significant for the teacher educators is not that Slowmation is an innovative and novel activity for preservice teachers to use in classrooms with their students, but that slowmation has been used in a way that encourages preservice teachers through discussion of their experience to articulate and synthesise their developing understanding of pedagogical knowledge. Such discussions appear to place them well down the path in their journey to building the coherent pedagogical knowledge they need to be an expert science teacher.

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INFLUENCE OF THREE FORMS OF INSTRUCTION ON THE RETENTION OF GIRLS AND BOYS ON THE EXAMPLE OF OUT-OF-SCHOOL-LEARNING SETTING ZOO

Barbara Kummer

University of Leipzig, Institute for biology I
Johannesallee 21/23
04103 Leipzig, Germany

email: bkummer@uni-leipzig.de

Christoph Randler

University of education of Heidelberg
INF 561-2
69120 Heidelberg, Germany

email: randler@ph-heidelberg.de

ABSTRACT

The focus of the paper is the question whether a teacher-centred "tour through the zoo" is more effective in terms of learning and retention than a learner-centred, group-based work following the self-determination theory Deci & Ryan. So far there are no surveys on the short-term and long-term success of these cognitive forms of education at the zoo. In addition, two forms of learner-based instructions were tested: group-based work followed by peer-tutoring and group-based work followed by a teacher-centred instructional part.

The data were collected using paper and pencil test. The cognitive evaluation divided into pretest, posttest and follow-up test.

Keywords: *empirical study, emotion, out- of- school learning settings, gender diversity*

1. THEORETICAL BACKGROUND AND OBJECTIVES

The focus of instruction at zoos as a place of learning is the encounter with the living animal. The pupils will receive insight into the biological basis and laws (adaptations) through their own observations and experience and recognize their importance for present and future life situations.

This teaching is based on self-determination theory by Deci & Ryan (1985), i.e. there is a lot of emphasis on autonomy, competency and social relatedness. These three universal basic needs support the intrinsic motivation and forward interest. A supportive self-motivation has a positive effect on the school interest.

Furthermore the theoretical basis of the study is both the moderate constructivism (Duit, 1995) and recent studies from the motivational psychology (Gläser-Zikuda et.al. 2005).

Cognitive psychology believes that contents are better retained if the teaching is more action-oriented (Deci & Ryan, 1985). Action orientation is inspired by constructivism, that is active and self-directed learning leads to self-knowledge. Only what the pupils themselves worked out is actually learned. The pupil does not adopt the given knowledge of the teacher wholesale but also the pupil has their own meaning to new material. Applied to the subject biology, this means all the more the pupil can operate independently and for example observed biological facts on the animal itself so much better the pupil will retain the knowledge.

There already exist studies which show that emotions affect the learning behavior (Gläser-Zikuda et al., 2005). According to psychology we remember more easily to emotional situations. Sensory perceptions such as primary experience in biology through observation of animals promote learning. Lessons the pupils are interested are better kept in their mind because the lessons are important for the pupils and intrinsically motivating.

The study checks the validity which self-determination theory, constructivism and findings of the motivational psychology can be applied to the transmission of knowledge at zoo as a place of learning.

It examines the following forms of instruction:

- group-based work (learner-centred) with the evaluation by pupils (peer-tutoring)
- group-based work (learner-centred) with the evaluation by teacher and pupils
- presentation of learning content by teacher (teacher-centred) in the form of a tour through the zoo.

Furthermore the research questions are:
1) What is the relationship between emotions such as interest, physical well-being, boredom and learning?
2) What are the differences in retention of girls and boys?
3) What are the differences in retention between pupils of secondary school and secondary modern school?

2. METHODS

A quantitative empirical study was carried out in the zoological garden of Bernburg (Germany, Saxony-Anhalt). 845 pupils of the fifth and sixth grade (10 to 13 years of age) participated in this study: 415 pupils of secondary school and 430 pupils of secondary modern school participated in the study. Studies show that zoological topics of interest to particular pupils of the orientation course pupils only attend the fifth und sixth grade. The selection of animals that were observed was based on the observation possibilities and of their adequacy to their habitat. The assignment of the classes in the different treatments (group-based work with the evaluation by pupils, group-based work with the evaluation by teacher and pupils, presentation of learning content by teacher, in the form of a tour through the zoo) was randomized. The division of groups within a class was also randomized. The data were collected using paper and pencil tests. The experimental approach followed a BACI design (before-after/control-impact) to control for confounding variables (Randler & Bogner, 2009). To check the effect of repeated testing after Keeves (1998) pupils are also tested who visit the zoo but not did participate in any treatment (control group). Before the day of study all pupils participated in a pretest to determine their previous knowledge. On the day of the study the pupils wrote a group test to determine the knowledge after the group-based work. After the execution of the specific form of instruction pupils wrote a posttest to check the knowledge after they heard details about all animals. It follows the emotional evaluation using state questionnaire (multiple choice items, open items). Six weeks after the zoo visit the follow-up test was carried out in the school.

3. RESULTS

The empirical study will be completed in February 2010. The first results are expected in May 2010.

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ANALYSES OF UNIVERSAL SOCIO-CULTURAL AND HUMANISTIC VALUES IN SCIENCE AND TECHNOLOGY COURSE BOOKS IN TURKEY

Ahmet Kurnaz

Department of Educational Sciences, Faculty of Education,
Aksaray University, Aksaray - TURKEY

Tuncay Tunç

Science Education Department, Faculty of Education,
Aksaray University, Aksaray - TURKEY

tctunc@gmail.com

Emrah Emre Özkeskin

Department of Computer Education and Instructional Technologies
Aksaray University, Aksaray - TURKEY

eozkeskin@hotmail.com

ABSTRACT

The new primary education curriculum has been prepared in line with the constructive approach and was put into practice in every elementary school of Turkey in 2005-2006 session. Therefore, course books, student workbooks and teacher guide books for science and technology course have been developed according to philosophy of this curriculum.

In this research, the universal socio–cultural and humanistic values in 6^{th}, 7^{th} and 8^{th} grade science and technology course books are investigated. This study showed that in 6^{th}, 7^{th} and 8^{th} grade science and technology course books; interested in all life, curiosity, healthy life values were the most studied; respecting/appreciation, loving the nature, different places, gratitude values were partly; unity/interdependence, friendship, happiness, compassion, citizenship, bravery, mercy, leadership, sharing, trust, patience, forgiving, stoicism, time management, generosity, discrimination and self–analysis were very rare. Optimism, tolerance, truthfulness, frugality, self–control and honest values were never studied.

Keywords: *Socio-cultural and humanistic values; Science and Technology; course books*

INTRODUCTION

Human and value relationship and problems that are connected are, wide scope and can be studied in different aspects. It's known that there are types of values like ethic, aesthetic, religious etc. However, their content and clarity are different, all values are common in the view that, they are created by human beings, acted by human beings. On the basis of the actions occurring and the acts coming true in human and the culture world, again the meaning and the values created by human lies.

Socio-cultural and humanistic values which are accepted as universal are (Doğanay, 2006);

a) Love (mercy, friendship, generosity, compassion, loving the nature)
b) Inner peace (frugality, happiness, patience, self-control, respect, healthy life, stick ability)
c) Truth (universal love, curiosity, discrimination, self-analysis, being interested in whole life)
d) Right Conduct (honesty, courage, leadership, time management, unity, gratitude)
e) Avoiding Violence (forgiving, citizenship, optimism, tolerance, sharing, truthfulness)

Value education is done by implicit curriculum and teaching affective behaviors to the students. Implicit curriculum, as a part of learning process at schools or in classrooms, consists of knowledge, values, attitudes and beliefs, which are generally unnoticed or unconsciously given (Horn, 2003).

When organizing the scientific attitudes and values in Science and Technology Course 6th, 7th and 8th Grade curricula, a categorization which consists of five categories was used. This categorization consists of easy to difficult, student's perception of happenings on their environment willingly, responding positively according to the situation, developing positive attitudes, organizing these values in her/his self-esteem and lastly developing a positive living style including positive attitude and values, phrases. In the section of learning areas and units, there is a list of attitudes and values which are desired to instruct to the students.

METHOD

As search scanning model, document survey technique was used. Document survey covers the analysis of the written material which includes knowledge about the fact or the facts which are intended to be searched (Yıldırım and Şimşek, 2005). To this end, in the course books which are thought at the 6th, 7th and 8th grades, it is stated that how many places or activities include universal values implicitly or explicitly. The data collected from qualitative studies, are analyzed in two ways as descriptive and content analysis (Strauss & Corbin, 1990). In this study data were analyzed using descriptive analysis. In addition determined the state of how the values are thought.

Findings and Comment

In this study, the question of "How and how much humanistic values teaching takes place in Science and Technology books in Turkey?" was tried to answer. For this aim, the outcomes of socio-cultural and humanistic values, accepted as universal and grouped under five major titles are listed below. In Table 1, under main titles, according to the classroom levels, values' teaching states are shown.

Table 1. According to the main titles, how many times values were studied in Technology and Science Course Books

VALUE	*6thGrade*	*7th Grade*	*8th Grade*	*TOTAL*
Truth	130	132	123	385
Inner peace	40	52	27	119
Love	12	18	12	42
Right Behavior	12	9	11	32
Avoiding Violence	3	3	7	13
TOTAL	197	214	180	591

OUTCOMES

1. Under the love value, "loves the nature" is the most studied in the 6th, 7th, 8th grade course books. The least studied value is generosity.
2. Under the inner peace value, the most studied value is healthy life in the 6th, 7th, 8th grade course books. Frugality and patience values weren't studied at all.
3. Under the truth value, the most studied values are curiosity and being interested in life values in the 6th, 7th, 8th grade course books. The least studied value is generosity.
4. When all the 6th, 7th and 8th grades are considered; under the "right behavior" value, "appreciation" value, is the most studied behavior. While time management and leadership values are studied a little, it's seen that honesty value wasn't studied at all.
5. When all the 6th, 7th and 8th grades are considered; under the "avoiding danger" value "citizenship" is the most studied behavior. While forgiving, sharing and trust values are similar and they were studied minimal level, time management and leadership values were studied in minimal level, optimism, tolerance and truthfulness were never studied.

6. When socio–cultural and humanistic values inspected under main titles, “truth” and “inner peace” were studied the most, love and right behaviors values were studied in average level, avoiding danger was studied the least in the course books.
7. When the universal socio–cultural and humanistic values in the course books are investigated under sub titles:
    a. Interested in all life, curiosity, healthy life values were the most studied;
    b. Respecting/appreciation, loving the nature, different places, gratitude values were partly;
    c. Unity/interdependence, friendship, happiness, compassion, citizenship, bravery, mercy, leadership, sharing, trust, patience, forgiving, stoicism, time management, generosity, discrimination and self–analysis very rare;
    d. Optimism, tolerance, truthfulness, frugality, self–control and honest values were never studied.

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WHO'S THAT GIRL? WHY GIRLS CHOOSE SCIENCE – IN THEIR OWN WORDS

Marianne Løken

The Norwegian Centre for Science Education, University of Oslo

marianne.loken@naturfagsenteret.no

Svein Sjøberg

The Department of Teacher Education and School Development (ILS)
University of Oslo

svein.sjoberg@ils.uio.no

Camilla Schreiner

The Norwegian Centre for Science Education,
University of Oslo

camilla.schreiner@naturfagsenteret.no

ABSTRACT

The PhD study's paramount objective is to develop knowledge about girls who choose to study subjects where females are in minority, in an effort to help break down the barriers that prevent other girls from doing the same. The informants are first- and second-year college and university students in Norway. Through a qualitative narrative analysis of seventeen written stories in which these girls describe and justify their educational choices, I will describe what opportunities they see that other girls are missing and show how they experience being a minority group. This research may be informative for future initiatives towards better gender balance in higher education.

Keywords: *Gender, choices, values, recruitment*

INTRODUCTION

Few young people are choosing to study STEM (Science, Technology, Engineering and Mathematics) at the tertiary level. The worlds of academia, industry and politics are calling for more scientists and engineers, and the media are writing about a recruitment crisis. Meanwhile, more young people than ever before are taking higher educations. In many countries, the percentage of women in tertiary education has exceeded 50 per cent. For some reason, the story is different in science and engineering. STEM disciplines are struggling to recruit students, especially female students. Politicians and institutions of higher education are touting the unexploited potential of European women, also because girls do at least as well on international tests that measure skills and knowledge. Others justify the need for women in STEM by contending that subjects need 'female values'. Both arguments take their point of departure in society's needs more than in the individual's needs. Among other things, I will discuss the arguments in the light of the girls' own stories, relevant empirical data and theories inspired by sociological, anthropological and gender theory perspectives.

Over the past 30 years, large resources have been spent on recruitment measures to the STEM sector. These actions have been more or less successful. Certain niches in science and technology have seen short-term booms, but the big picture has not changed in line with the incentives, especially not if one compares the trend with the number of women studying other subjects. We know a great deal about adolescents' attitudes to STEM (Schreiner & Sjøberg, Eurobarometer, etc.) and young people's academic performance (TIMMS, PISA. etc.), but we have little documented knowledge about what it is that makes certain girls choose STEM, where females constitute a small minority. To help reduce this gap in our knowledge, I will discuss the possibilities these girls see that others do not see. I will use the women's own stories to break down barriers, identify opportunities and, hopefully, develop more effective interventions for recruiting more girls to STEM.

METHOD

The girls in the sample are first- and second-year college and university students in Norway between 18 and 22, who have chosen to study STEM subjects where females are in minority. The stories were collected in autumn 2009 (www.naturfagsenteret.no/skrivdittvalg).

I will make a narrative in-depth study of seventeen out of a sample of seventeen written stories in which the girls describe and justify their educational choices. The methodical approach has been chosen to understand, describe and explain the girls' choice of STEM, based on the understanding that the structure of text is the structure of meaning. To systematise the stories, I am using the programme NVivo.

I take an interdisciplinary approach to the study. The project uses a phenomenological research approach and focuses on the girls' life world and their understanding of it, where interaction, relationships and language play key roles. I have chosen a qualitative narrative approach to shed light on the relationship between girls' self-image, identity, expectations of mastery, roles and interests, and their choices in relation to STEM. In so doing, I am linking this research project to a view that emphasises individuals' understanding and perception of their place in relation to their surroundings.

The study is designed as a longitudinal study where the goal is to follow young women through higher education and into the world of work, to be able to document knowledge about women who choose, study and embark on careers in science, technology, engineering and mathematics.

RESULTS

The narratives indicate that the girls who choose STEM differ in many ways. However, all of the seventeen informants describe barriers in the form of myths and prejudices, experience of being alone and different; that the girls who choose STEM do not fit into the stories told about scientists and engineers. These girls are highly motivated for success, and they are resolute and determined despite some descriptions of serious objections from their surroundings since childhood. Another common characteristic of the stories is the part played by the parents. Fathers play an especially important role, even in families where the mother or other close relatives have a scientific background. The girls describe different experiences with STEM during childhood, for better or for worse, and they have different experiences from elementary school and high school. Several state that they feel at home in classes with others who strive for good grades and are good students. Their interest in STEM is often described in positive and emotional terms. Mathematics and physics are mentioned as whetting their appetite for STEM. All the girls describe themselves as social, although some are more socially aware than others, while all the authors are concerned about mastering and completing the goals they have set. The stories bear witness to finely honed linguistic awareness and mature thoughts in connection with the girls' own choices.

CONCLUSIONS

Based on analyses of the girls' own stories, I discuss the findings in the light of existing empirical data on girls who opt for STEM. The results are therefore considered in connection with analyses of data from the quanitative questionnaire surveys in the Norwegian "Vilje-con-valg" research project conducted in autum 2008 and the collaborative EU funded research project IRIS – both projects addressing challenge that few young people, and women in particular, choose education and career in STEM. The findings are described and discussed to develop new knowledge about girls educational choices. This research will hopefully raise the awareness of why some girls choose science, and may be informative for future initiatives towards better gender balance.

This research is hopefully informative for professional advisers, science education organizations and politicians as it will raise awareness of why some girls choose to study subjects where females are in minority – in an effort to improve the recruitment of girls in to science.

The analyses will be the point of departure for the further follow up of the girls through in-depth interviews with emphasis on findings from the analyses of the narratives, followed by focus groups to discuss possible interventions and initiatives.

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ENHANCING STUDENTS' MOTIVATION AND INTEREST WITH SCIENCE INQUIRY ACTIVITIES AND OUT-OF-SCHOOL VISITS

Anni Loukomies

Department of Teacher Education/University of Helsinki

anni.loukomies@helsinki.fi

Jari Lavonen

Department of Teacher Education/University of Helsinki

jari.lavonen@helsinki.fi

ABSTRACT

A teaching module that includes inquiry activities, an industry site visit, and activities related to reading and writing, was designed following principles of design-based research (DBR), implemented, and evaluated. The module includes several features intended to promote students' interest and motivation towards science and science related occupations. The features are based on the Self-Determination Theory (SDT) of Deci & Ryan and interest theory of A. Krapp. During the design process, data were collected about how students (ages 13-15, N=139) with different motivational orientations, and teachers, experienced the module, and the motivational features of it. Based on the data analysis it is discussed which ones of the designed features really were motivating in the students' and teachers' opinion.

Keywords: *motivation, interest, out-of-school learning, site visit, inquiry activities*

INTRODUCTION

The problem of decline in young people's interest in science, and in pursuing scientific careers, is a significant concern of science education researchers, but an effective way of solving it is absent. Osborne, Simon & Collins (2003) argue that research on motivation should be taken into account when searching for possible solutions to the problem. The concept motivation in this study is examined in the light of self-determination theory (SDT) (Deci and Ryan, 2004). According to SDT, motivation style may be *autonomous* (*self-determined)* or *controlled,* or motivation can be missing, at which point person is *amotivated.* Autonomous motivation exists when people experience satisfaction of their basic psychological needs that are needs for autonomy, competence and social relatedness. Interest has close relationship to intrinsic motivation and experience of self-determination. Interest is a content-specific concept, and it encompasses feeling and value related components (Krapp, 2007). Interest can be personal or situational. Situational interest is aroused by something in the environment, and it may develop into more persistent personal interest.

Based on the literature review and analysis of teachers' needs, a teaching module was designed following principles of Design Based Research (DBR). There are several motivation and interest supporting features, based on the SDT and interest theory, included in the module. The module includes inquiry activities, an industry site visit in an authentic context, and activities related to reading and writing. In more detail, students prepare themselves to the visit with inquiry and ICT tasks. During the visit they see science and technology (S & T) applied in an authentic context, meet people who work in the field, and ask them questions. After the site visit, students process the information gathered in the visit further by writing articles and constructing concept maps.

The research questions is: How do students and teachers experience the module, especially features intended to promote interest and motivation towards science and science related careers, and to what extent did the students' and teachers' experiences meet the ideas of the designers?

METHODS

The module was designed using DBR approach that aims to improve educational practice. Juuti and Lavonen (2006) summarise DBR as follows: 1) DBR takes place in iterative cycles of invention and revision, starting from a need for change in practice, then proceeding to theoretical problem analysis and defining aims for a design solution, and finally finishing up to design and production phase. 2) DBR is collaborative, interventionist and generates a widely usable design solution that is directly applicable in praxis, and 3) DBR provides new educational knowledge. In the knowledge acquisition process, multiple methods are used.

In the process of generating new educational knowledge about possibilities of enhancing students' motivation and interest with the designed module, several sets of data were collected. Students' (N=139), ages 13-15, motivation orientations were examined with the Academic Motivation Questionnaire (AMQ) based on the SDT. Students were classified by K-means cluster analysis into groups *amotivation, controlled motivation* and *autonomous motivation.* Representatives of each group and the teachers were interviewed with a semi-structured interview, and activities were videotaped. Interview data as well as data from the content analysis of the module were categorized based on SDT and interest theories. The interview and video analysis results were compared to the results of the module content analysis. Thus it is possible to discuss which ones of the designed features really were motivating in the students' and teachers' opinion.

RESULTS

There are two outputs of the research: a theory based design solution, a novel teaching module, introduced in the introduction chapter, and new research based knowledge on motivational features of the module. Based on the content analysis of the module, it can be argued that the module includes features that support students feeling of autonomy, competence and social relatedness, and also the feeling and value related components of students' interest. Based on the interviews, students and teachers found the authentic context, meeting people who worked in the field of S & T, and possibility to work in collaborative groups the most motivating features of the module. However, students did not experience as much support for their feeling of autonomy and value related component of interest as it could have been expected based on the content analysis of the module.

CONCLUSIONS

In spite of students' motivation orientation, the interviewed students had positive feelings about the module, especially the site visit. Support for the feeling of social relatedness was important for them. They enjoyed working in groups and spending time together with their classmates. However, only few of the interviewed students mentioned that it was enjoyable to study together towards a common aim, not just spend time with friends. Support for the feeling of social relatedness in the direction of the aims of the module is an issue to be emphasised, In other words, value-related valence of interest has to be supported alongside the feeling-related valence. Thus the module would not just be an enjoyable experience solely constrained to the affective domain students' interest, but it could be a way of helping students to understand the relevance of their own science studies.

Possibility to see S & T applied in an authentic context was an important motivation promoting feature for the students. As a form of out-of-school education, the module appears to be well suited for enhancing students' motivation and interest towards science and related careers. Out-of-school visits also help students to improve scientific literacy in society, understand how S & T is applied, and inform them of the career possibilities in industry (Braund & Reiss, 2004). Students considered the visit relevant to their interest, which was an essential aim in our design process. Especially remarkable was that the amotivated students' critical eyes were opened for seeing the relevance of their science studies from the point of view of connecting school science and science applied in authentic settings in various fields. Furthermore, our model included activities of learning through reading and writing. The articles, written by the students, demonstrate that S & T has become closer to the students.

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EZI EDUCATION- AN INNOVATIVE INITIATIVE TO MAKE EDUCATION FOR ALL A REALITY

Jashree A. Mehta

Director/SATWAC foundation

Email: satwac@gmail.com

ABSTRACT

Lack of education is one of the major challenges faced by developing world today. While lot of efforts are underway to enhance reach of education by opening new schools, hiring & training more teachers, and other conventional methods, an initiative in Gujarat, an Indian state, has tried "out of the box" thinking to solve this problem. Ezi Education project is an initiative which leverages modern technology, innovative model and creative delivery mechanism to make science and mathematics education Affordable, Accessible and Effective.

The paper will discuss this initiative, guiding principles and success/limitation factors.

Keywords: Science *Education, Technology, Satellite Communication, Multimedia.*

INTRODUCTION

In the new millennium, knowledge will dominate. New technologies acquired through knowledge will play a key role to improve human life, especially in the developing part of the world. As the world economy is undergoing the transition stage, the significance of the developing nations is rising as they have become the major growth drivers. While these economies embark on the growth path, there are several challenges on socio-economic front acting as barriers to development. Education is a key potential growth disrupter and a grave challenge being faced by all the emerging countries. Although the governments in these countries are making impressive budgetary allocations for education expenditure, the reach (access) and quality of education still remain one of the major bottlenecks.

In most of the developing countries especially countries with large geographical footprint, biggest challenge is limited access to science education. It is very difficult and economically unviable to have a fully equipped and well served school in each village. As these villages are at a substantial distances and lack transportation infrastructure the current practice of one school for a group of villages is not effective. Further very low pupil/teacher ratio (40.2% for primary and 32.7% for secondary education) hence poor attention of teachers, lack of Science laboratory or other educational tools, under-qualified and under-trained teachers, no education help at home (as many students are first generation learners) make it very difficult for students to pass the final year of the high school (10th grade) public examination. The average result for the last few years has been less then 50%. The majority fail in Science and Mathematics. Poor education leads to high drop-outs and low pass rate which means that small percentage of total population are able to enter higher education (13% reach college) and even smaller percentage (less than 3%) are able to make it to professional courses.

METHODS

Chronic problems faced by Indian education system (and also majority of highly populated developing countries) today can only be resolved by innovative use of technology. **Ezi Education** is a creative experiment to help underprivileged students in urban poor and rural areas of Gujarat (one of the state in India with population of 60 Million + people). Ezi Education project was conceived around basic premise of leveraging technology to create user friendly, mass centric, and economical solution to solve basic problems of inherent education system. The project aspires to universalize the education across India by making high quality science educational contents available to all hence bridging the opportunity divide.

The project comprises of two complementary initiatives, first being EziBox based Interactive Education Network and second being Ezi Education Channel. The end user can avail these services on a simple television (Accessible to 94% of people across Gujarat). It is India's first dedicated 24x7 channel providing science and mathematics education for 10th Grade students in Gujarati & English medium delivered by expert faculty on the Television at no cost to the students. To access the channel a student needs access to television with a local cable connection. The channel reaches to more than 2.5 Million homes across Gujarat.

EziBox works on a simple delivery mechanism. Contents (Video & Multimedia) are created in the studio. It is placed at student end connected to his/her Television or any kind of monitor. Contents are beamed to EziBox from Satellite Hub. Student receives contents in EziBox and views like a normal T.V. channel. Students can get solution of their queries via email or by calling toll free number while on every Saturday and Sunday, Live sessions are scheduled in which student can directly interact with teachers through EziBox. Student can even hear questions asked by other students and also watch the solutions given by the teacher for respective questions. EziBox has a feature to store a lecture so student can store any lecture and watch it as many time as he wants. Study Material of the respective lecture is being beamed to the EziBox before 2 hrs of every session, so that student can refer material before attending the session.

What makes EziBox more attractive is the fact that all of these are made available thru one device and that too on the existing Television of the users. EziBox, an End to End IP Box, will bring a host of customized applications, including Computing, Internet, Education, Social Networking, Entertainment, and High Quality Video Communication to name a few, on the Television Sets for the user.

RESULTS

EziEducation project makes it possible to

- Have interactive session on various subjects by expert teachers and professors from remote location, providing answer to coaching needs of students whether for school or any preparatory exam, reaching hundreds of students.
- Connect Rural Schools where teachers are scarce resource providing basic education services like primary education to children of all villages and other remote areas.
- Make rural schools more effective, by using virtual class-rooms which include live interactive sessions, multimedia teaching aid and pre-recorded content.
- Create knowledge communities where different groups and peers can learn and share knowledge, perception and ideas amongst them using cutting edge technology.

CONCLUSIONS

New emerging technologies and concepts like EziEducation will lead to new methodologies which will enhance the spread of education. EziEducation will leverage technology to not only eliminate inherent constraints in remote areas but also redefine the way education is delivered in urban areas through classical class-room approach. Thus, the benefits of latest communication revolution in providing education and training of desirable quality will change the way education is delivered in urban as well as rural areas. EziEducation is a beginning which can help:

- Remove Geographical Constraints in Science and Mathematics education
- Tackle Vital Issue of Scarcity of Quality Teachers & Faculty
- Make Education interesting and interactive for students
- Implemented Cost effectively

Extensive research is being carried out on how this next generation technology paves the way forward to better and more educational learning.

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INTERACTIVE TEACHING AT AN OUT-OF-SCHOOL LEARNING SETTING REVEALS SPECIFIC COGNITIVE SUBSAMPLES FOR IMPROVEMENT OF SCIENCE INSTRUCTION

Barbara Meissner
University of Bayreuth
Chair of Biology Education
barbara.meissner@uni-bayreuth.de

Franz X. Bogner
University of Bayreuth
Chair of Biology Education
franz.bogner@uni-bayreuth.de

ABSTRACT

Science education is expected to integrate outreach projects into classroom learning. Constrained working memory capacity is a limiting factor: Cognitive load is supposed to be high at out-of-school learning settings especially if the project comprises hands-on activities. The main objective of our study was to identify potential relations of cognitive and motivational factors in students taking part in an interactive out-of-school lesson and thus, to enhance vital out-of-school science education. Central questions were: To what amount is our lesson designed adequately with respect to cognitive load parameters? How can general starting points for instructional optimisation be identified and characterised?

276 students (M_{age}=11.6$\pm$1.6) participated in the lesson illustrating properties of salt (NaCl). Content-related comparison and cluster analyses resulted in seven preknowledge/performance subsamples. Standardised mental effort and instructional efficiency allowed specific description of each subsample. Suggestions will be made how particular amounts of different kinds of cognitive load in working memory could explain these results. Motivational analyses confirmed and refined the classification. The results revealed possible implications for future out-of-school science instruction.

Keywords: *science education, out-of-school, interactive, cognitive load, instructional efficiency, instructional involvement*

INTRODUCTION

Out-of-school science education emphasises the need to integrate outreach projects into classroom learning (Hofstein, & Rosenfeld, 1996). The main limitation is the diversity of influence factors at out-of-school learning settings that mainly correspond to the novelty space (Orion, & Hofstein, 1994) resulting in enhanced cognitive load due to the novelty of an out-of-school learning setting. This is a critical point considering that students are expected to demonstrate clear cognitive achievements after participating in a curriculum-based outreach project. Cognitive load theory (Sweller, van Merrienboer, & Paas, 1998) differentiates between extraneous cognitive load due to layout/surroundings, intrinsic cognitive load due to complexity and difficulty of a task, and germane cognitive load as a result of learning processes. Extraneous cognitive load is supposed to generally be high at out-of-school learning settings. If a lesson comprises hands-on activities (e.g. science centres/out-of-school laboratories), this effect is exacerbated as these tasks are well-known to increase cognitive load. The application of cognitive load theory on instructional design should aim towards reduction of extraneous, fostering of germane, and adequate level of intrinsic cognitive load (Sweller, van Merrienboer, & Paas, 1998).

In our study, we developed an interactive out-of-school lesson following the principles of cognitive load theory. The lesson comprised simple experiments to illustrate essential properties of salt (NaCl). The project aimed to combine curricular topics with the inclusion of out-of-school experiences into scholar daily life. The main research questions were: To what amount is the lesson designed adequately with respect to cognitive load parameters? How can general starting points for instructional optimisation be identified and characterised?

For this purpose, we analysed subsamples of students with different preknowledge and performance scores. The main intention was to identify possible relations of cognitive and motivational factors in students taking part in an interactive out-of-school teaching unit. The aim was to evolve ideas for effective development of curriculum-based outreach projects, and thus, to enhance vital out-of-school science education.

METHODS

276 students (M_{age}=11.6$\pm$1.6) accomplished the out-of-school lesson. Five experiments illustrated freezing point depression, electric conductivity, endothermic resolving processes, density increase, and osmotic activity. Applying knowledge-tests, we measured preknowledge and performance. The students rated mental effort on an unidimensional seven-point scale (van Gog & Paas, 2008) each time after completion of a workstation. To develop subsamples according to preknowledge and performance, we conducted content-related comparison, followed by comparative cluster-analyses (c = 0.84). We compared standardised mental effort mean scores, instructional efficiency (van Gog & Paas, 2008), and motivational parameters (e.g. instructional involvement - Paas, Tuovinen, van Merrienboer, & Darabi 2005) of each cluster.

RESULTS

Content-related comparison and cluster analyses resulted in seven subsamples labelled according to pre-knowledge/performance: I-“low/middle”, II-“low to middle/high”, III-“middle/low to middle”, IV-“middle/middle to high”, V-“high/low to middle”, VI-“high/none”, VII-“middle/none”. Standardised mental effort and instructional efficiency scores allowed specific description of the subsamples (cf. Table 1). Motivational analyses confirmed and refined the results (cf. Table 1).

Table 1. Standardised mental effort mean scores, instructional efficiency and instructional involvement scores of each cluster, related to total sample average scores

#	I	II	III	IV	V	VI	VII
Mental effort	Below	Below	Approx.	Above	Approx.	Below	Above
Instructional efficiency	Above	Above	Approx.	Above	Below	Below	Below
Instructional involvement	Approx.	Above	Approx.	Above	Approx.	Below	Approx.

CONCLUSIONS

Suggestions will be made how particular amounts of the different kinds of cognitive load in working memory could explain the results. Students of cluster VII, for example, may experience too much extrinsic cognitive load due to the learning setting itself so that there may not enough capacity be left for learning processes (i.e. germane cognitive load). Calculation of instructional efficiency and instructional involvement – both parameters based on mental effort and performance scores – proved to be an appropriate method to analyse learner characteristics in an interactive out-of-school science lesson. We succeeded to characterise subsamples in a way that revealed 1) statements about the design of the lesson and 2) possible implications for future out-of-school science teaching. For example, our data emphasize the importance of adequate guidance.

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A THEORETICAL FRAMEWORK BASED ON A CONSTRUCTIVISTIC REALISM FOR SCIENCE EDUCATION GOALS

Zahra Niknam

Tarbiat modares University

Z_niknam@yahoo.com

Khosrow Bagheri Noaparast

University of Tehran

kbagheri4@yahoo.com

ABSTRACT

The present research deals with philosophy of curriculum in Islamic Republic of Iran. It is argued that neither realism, understood as naïve realism, nor constructivism can provide a tenable basis for a proper philosophy of curriculum in science education. Instead, an alternative is suggested as constructivistic realism. While it is held here that there is a reality that science deals with, it is not the case that this reality can be achieved easily and directly. The only way is to use our constructs to capture the reality. These constructs are built by means of our imaginations as well as our values.

Key words: *Philosophy of curriculum, constructivism, realism, science education*.

INTRODUCTION

Epistemological foundation of curriculum and science education has been debated by two strong rivals, namely realism and constructivism. Realism, in its naïve version, holds that reality is separate from the knower in a clear-cut way and that the knower can aim at the way things really are. On the other hand, according to constructivist philosophy, knowledge is a matter of construction without being concerned with the way things really are. We have argued that both realism and constructivism fall far short of fulfilling the promise of providing a tenable basis for science education; the former by underestimating the role played by our constructs and the latter by leading to subjectivism. Our alternative view is a constructivistic realism that embraces both the roles played by reality and our constructs in dealing with the reality. This view presses on imaginations, feelings, values and beliefs of the knower in providing constructs that try to capture the reality. The proper and successful science has indications of both our constructs and the reality. Accordingly, science education should encourage students to listen carefully to reality as well as performing free imaginations.

METHOD

This article includes a theoretical inquiry and has, hence, used the analytical method to investigate on the epistemological presuppositions of the views on science education.

REALISM AND CONSTRUCTIVISM IN SCIENC EDUCATION

Realism in its naïve version holds on reality as an existing entity separate from the knower and that the knower should seek it in providing the true knowledge. Thus, knowledge is the discovery of external reality existing outside the bodies of cognizing beings and independent of them. Science is then conceptualized as a search for truths and a means for discovering theories, laws and principles associated with reality. Realists assume scientific knowledge as an objective and absolute knowledge which can transfer effectively from teachers' heads to students' heads. Students play a completely passive role in learning science. This view underestimates the roles that might be played by fore grounded presuppositions and conjectures in constructing science about the external or physical reality. Thus, in science education, learners, at most, are encouraged to observe objects, events and phenomena with an objective orientation in which imaginations, feelings, values, and beliefs have no proper place.

In contrast, constructivism asserts that knowledge doesn't refer to an objective or an absolute knowledge. Knowledge has to be viewed as a human creative endeavor which is historically and culturally conditioned. This view is shared by most schools of contemporary philosophy of science that subscribe to the thesis of theory dependency of observation. Accordingly, knowledge is by no means a representation of the objective world because it isn't independent of the knower. So knowledge is not passively received, but it is actively built up by knower. To show the total scope of constructivism, one should consider it as a spectrum with two ends of sociological constructivism and psychological constructivism. While the latter emphasizes on personal, individual and intellectual constructions arising from the activity of persons, the former maintains that scientific knowledge is socially constructed and vindicated. Faced with some critiques, it is said, especially with regard to the validity of knowledge, constructivism may lead to a kind of "anything goes".

CONSTRUCTIVISTC REALISM IN SCIENCE EDUCATION

In a research titled "A *study on the system of values and beliefs in The Islamic Republic of Iran, formulating a relevant philosophical foundation for curriculum*" (Bagheri et al., 2008), constructivistic realism is suggested as the relevant basis for curriculum in the country. This study is based on the findings put forth in a previous research about the place of philosophy of education in The Islamic Republic of Iran (Bagheri Noaparast, 2008) in which the epistemological foundations and principles of education is derived from Islamic teachings. According to the “constructivitic realism”, natural sciences are endeavors in order to know the reality of natural phenomena, but due to the complexity of reality, it is inevitable to make mental constructs and examine them and thereby provide evidence for their relevance to the reality. Thus, in science, both the reality and the scientist play their proper roles. This means that "epistemological foundations of education have two aspects: one related to the knower and the other to the known." (Bagheri Noaparast, 2007, p. 171). These two aspects of science are regarded in suggesting the view of "constructivistic realism". In this term, "realism" refers to exploratory dimension of science, that is to say, science deals with the reality of "something". Correspondence to reality, even thought not in its naïve version, is held as a criterion for the truth of knowledge claims. On the other hand, when science is considered from the side of the knower, constructive features of science come to the fore. Two major features that are related to this aspect of science are invention and correspondence with the human needs. As far as the invention is concerned, scientists are people make the science by means of their creativity and imagination in trying to understand the known. Also, correspondence of science with human needs refers to the role and involvement of scientist during the construction of science. This will show why and how scientists have selective views in doing science in order to resolve individual and collective needs. There isn’t any contradiction and conflict between the exploratory and constructive features of science. These two features are highly intertwined. Thus, science cannot be seen solely from either the first or the second perspective. To have a correct picture, we should take science as an endeavor to capture the reality by and in terms of our constructs (Bagheri Noaparast, 2007).

GOALS OF SCIENCE EDUCATION IN CONSTRUCTIVISTIC REALISM

According to constructivistic realism, science education has three main goals: 1) acquiring knowledge about natural phenomena; 2) acquiring insight about natural phenomena; and 3) acquiring skills to use and manipulate natural phenomena responsibly. The insight about natural phenomena comes from values and cultural presuppositions that might be inspiring in developing our constructs to capture the reality.

CONCLUSIONS

This article is part of a wider research on the philosophical basis of curriculum in The Islamic Republic of Iran. We tried to explain constructivistic realism as a proper epistemological view for science education**.** Constructivistic realism is different from both naïve realism and idealistic constructivism. Unlike the naïve realism, it does not hold on science as a definite and straightforward knowledge and contrary to constructivism, it tries to limit our imaginations and values by appealing to reality. Science must be seen as constructs that have already been justified, but one should not imagine that they remain immune to change. Constructivistic realism opens a space for more consistency between science and cultural values in society because constructs are held to be built by means of our imaginations as well as our values to capture the reality.

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THE USES AND ROLES OF SCIENCE IN SOCIO-SCIENTIFIC DECISION-MAKING CONTEXTS

Jan Alexis Nielsen

University of Southern Denmark

jan@imada.sdu.dk

ABSTRACT

This presentation presents the preliminary results from a qualitative multiple-case study of Danish upper secondary school students' critical discussions on socio-scientific issues. The primary question to be elucidated pertains to the place and functional role of articulations of scientific content and arguments in group-discussions that aim at making a group decision on a socio-scientific issue. In a nutshell: how do students synthesize between natural scientific content and systems of values – or systems of interpretations of values (such as the ones found in the humanistic/social sciences)? The author recognizes as important the recent trends within the argumentation strand in international science education of shifting focus to the dialogic (as opposed to monologic) articulation of argumentation - i.e. the process of producing argumentative moves in discussion contexts. It can be argued, however, that a thorough theoretical framework for conducting such research within science education is only on the horizon. The analytic framework, which is applied in this study is constructed as a hybrid of the pragma-dialectical theory of argumentation and a set of basic tools originating from conversation analysis. As such, the data is approached through a critical-dialectical methodology.

Keywords: *Argumentation, Critical Discussions, Decision-making, Socio-scientific Issues*

INTRODUCTION

Informed decision-making is typically thought of as being a necessary feature of critical citizenry. To be sure, we find decision-making skills appearing more and more explicitly in (inter)national formulations of educational goals for upper secondary school. It is important to recognize that the concept of decision-making involves much more than "simply" being informed from multiple disciplinary fields such as the natural sciences. Decision-making processes are first of all highly complex processes that are neither easily spelled out nor easily taught explicitly (e.g. Ratcliffe, 1997), one reason for this is that being informed from multiple disciplines only forms the basis for a decision. Decision-making processes requires the argumentative articulation of that information as well as critical reflections upon such types of discourse. As such decision-making processes are argumentative processes in the broadest possible sense of that term. This presentation presents the preliminary results from a qualitative multiple-case study of Danish upper secondary school students' critical discussions on socio-scientific issues. The primary question to be elucidated pertains to the *place and functional role of articulations of scientific content and arguments* in group-discussions that aim at making a group decision on a socio-scientific issue. In a nutshell: how do students synthesize between natural scientific content and systems of values – or systems of interpretations of values (such as the ones found in the humanistic/social sciences)? The end-product of this study is first and foremost a semantic framework for future understanding and categorization of interdisciplinary argumentative discourse.

THEORETICAL BACKGROUND

The study applies a theoretical approach to argumentation, which so far has only been mentioned in science education: the *pragma-dialectical* theory of argumentation (Van Eemeren & Grootendorst, 2004). On this account, argumentation is treated as a regimented means to resolve a difference of opinion - i.e. as something that has *functionality* in resolution processes. Thus, rather than focusing on the structural coherence of, or patterns in, students' argumentation involving science, this study investigates the specific *functions*, which students distribute to scientific content (over and against the functions of non-scientific content) in the process of reaching a decision. The pragma-dialectician understands argumentation *as the performance of complexes of speech acts that play a role in a dialectical resolution oriented process* (a critical discussion) (Van Eemeren & Grootendorst, 2004). In accordance with dialectics the pragma-dialectician not only analyzes the argumentation advanced by one party in terms of logical coherence, but, more importantly, also against the background of resolving a difference of opinion (*ibid*). To this end, extensive methodological guidelines for general argumentation analysis have been produced. The core of a pragma-dialectical analysis is to *reconstruct* the discussion as a regimented procedure oriented towards resolution of disagreement; and this involves, among other things, analyzing the performed speech acts in order to make explicit (1) the fundamentals of the dispute, (2) the often implicit standpoints, (3) the commitments and entitlements of the parties, (4) unexpressed premises, (5) the structural aspects of the argumentation, and (6) which argumentation schemes are being put to use (*ibid*).

METHODOLOGY

The objects of this study will be group-discussions in 4 biology classes in the Danish upper secondary school (grade 12). Data will consist of the transcribed video recordings of the face-to-face discussions (n=12-15). The discussions are contextualized in a decision-making activity that revolves around the controversial socio-scientific issue "gene-therapy as treatment?" The activity will have length of 2x45 minutes and it will be the concluding activity in a longer course on genetics.

RESULTS

The data from each group are analyzed in 4 steps: (1) *Surface indexing*: A placement of markers in the discussion that locates local articulations of (meta-) scientific content. (2) *Local deep analysis*: A fine-grained pragma-dialectical reconstruction and analysis of the local dialectic processes of the discussion in which a (meta-) scientific content was articulated. (3) *Systemic analysis*: A global and coarse-grained pragma-dialectical reconstruction of the entire discussion dialectics towards the groups' decision. (4) *Synthetic analysis*: An analysis of the place and role of the local, (meta-) scientifically content-full dialectics within the global dialectics. The data analysis is dialectical in the sense that it is foreseen that reiterated cycles of step (2) and (3) are necessary for an elaborate synthesis in step (4). One very preliminary result from the initial analysis is that there is an indication that when propositions that contain scientific content are the object of explicit differences of opinion at the early stages of the discussions it is easier for the participants to structure their decision-making process at later stages in the discussion.

CONCLUSION

There are preliminary indications that it is possible and feasible to operationalize the pragma-dialectical framework for analyzing socioscientific discussions within the science education field. More elaborate ways of distinguishing between the different roles of science in discussions will be provided in the presentation.

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DEVELOPING STRATEGIES FOR PROMOTING SCIENTIFIC LITERACY: COOPERATION FOCUSSING ON EMPIRICAL AND THEORETICAL CHALLENGES IN SOUTH AFRICAN AND SWEDISH CONTEXTS

Clas Olander
University of Gothenburg, Sweden
clas.olander@gu.se

Göran Lassbo
University of Gothenburg, Sweden

Paul Webb
Nelson Mandela Metropolitan University, South Africa

ABSTRACT

This paper aims at presenting a collaborative research project where South African and Swedish science educators participate. Central in our working process are joint workshops held with the aspiration of developing strategies that would promote scientific literacy; specifically, developing strategies that encourage participation from 'new' groups, for example, in respect of social, gender, and cultural aspects. In this paper we will suggest approaches which will enable learners to develop their creative potential in science classrooms through writing, talking, arguing and doing science.

Keywords: *Scientific literacy; second language; social language; writing, talking, arguing and doing science*

INTRODUCTION

The promotion of scientific literacy is, according to Roberts (2007), a key issue in education throughout the world, and one reason for this concern is the aspiration of greater participation in science and technology education. Developing strategies that encourage participation from 'new' groups, for example, in respect of social, gender, and cultural aspects are a challenging but necessary enterprise. In a broad sense scientific literacy is argued on account of economic, utility, democratic and social/cultural reasons (Millar, 1996). The factors above suggests a need for a new approach to science education, one that takes into account both the fundamental and derived senses of science (Yore & Treagust, 2006), and which will enable learners to develop their creative potential through reading, writing, talking and doing science.

Policy documents in both South Africa and Sweden emphasise the ambition of increasing the amount of students participating in further science education; right now there is a falling trend. One suggested way that would contribute to the engagement from 'new' groups is to acknowledge the role of appropriation of science language in science learning, especially a second language. In a broad sense scientific literacy is argued with economic, utility, democratic and social/cultural reasons, and we suggest a need for a new approach to science education, one that takes into account both the fundamental literacy skills, for example, writing and talking in science language and the derived senses of science, for example, making informed decisions as participators in a democratic society.

In South Africa, science results are poor, partly as a result of the historic legacy of Apartheid and because of language issues. Teachers are facing a difficult task and are, generally, poorly prepared. Thus theoretically well-founded developments of the practice of teaching and teacher training are of utmost importance if the situation is to be improved. In Sweden, interest in science is declining, both as a career and as a body of knowledge. Understanding and developing alternate ways of supporting scientific literacy is crucial for changing this trend in general, and language issues are becoming increasingly important, not only in South Africa, but also in Sweden where an increasing number of students have Swedish as their second language.

In South Africa the Department of Education has attempted to address the issue of developing scientifically literate learners via its recently developed National Curriculum Statement. The Natural Science Learning Area of the South African curriculum focuses on three 'Learning Outcomes': scientific investigations, the construction and application of scientific knowledge, and an appreciation of the interrelationships of science, society and the environment; areas which will form one of the core issues in this project.

The Swedish curriculum states in its first chapter that in terms of the compulsory school phase "The school has the task of imparting fundamental values and promoting pupils' learning in order to prepare them to live and work in society" (National Agency of Education,1994). The role of every subject is to support this aim and when it comes to science studies the syllabus is divided in three parts: knowledge of nature and Man, scientific activity and use of knowledge. This is a reflection of science as the products of science, the processes of science and the social implications of science. As such, both the South African and Swedish curricula call for learner development in scientific literacy (and concomitantly in teacher development). Nevertheless, indications are that in both these countries, and generally internationally, there has been but a slow awaking in terms of research findings in the fertile ground of scientific literacy, and very little practical implementation (Yore & Treagust, 2006; Roberts, 2007)

METHODS, RESULTS AND CONCLUSIONS

The South Africa/Sweden project collaborative efforts focus writing, talking, arguing and doing science, and the paper will discuss the aspects that we, so far, has focussed on: scientific investigations (doing science), use note books (writing science), and argumentation skills (talking and writing science). Central in our working process are joint workshops held with the aspiration of developing strategies that would promote scientific literacy; specifically, developing strategies that encourage participation from 'new' groups, for example, in respect of social, gender, and cultural aspects. In this paper we will suggest approaches which will enable learners to develop their creative potential in science classrooms through writing, talking, arguing and doing science.

Doing a scientific investigation, in brief, includes choosing an investigable question, formulating a hypothesis, perform the investigation and draw a conclusion. The procedure is documented in, for example, a note book where all steps are argued for (Webb, 2009). Argumentation, understood as connecting claims with evidence, is an important part of doing an investigation, and is a potentially influential skill in both the fundamental and derived sense of scientific literacy. Furthermore, we suggest that promoting code switching is essential – both between first and second language, and between social languages, principally colloquial and scientific languages (Olander, 2010).

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FIRST YEAR UNIVERSITY STUDENTS' CONCEPTIONS ABOUT LIQUID CRYSTALS IN SLOVENIA

Jerneja Pavlin

University of Ljubljana, Faculty of Education

jerneja.pavlin@pef.uni-lj.si

Iztok Devetak

University of Ljubljana, Faculty of Education

iztok.devetak@pef.uni-lj.si

Saša A. Glažar

University of Ljubljana, Faculty of Education

sasa.glazar@pef.uni-lj.si

Mojca Čepič

University of Ljubljana, Faculty of Education

mojca.cepic@pef.uni-lj.si

ABSTRACT

Liquid crystals are materials which are used in displays, phones, laptops, mp4 players etc. Although these materials are so common, occasional debates with students showed that they are aware of their existence but not much more. As liquid crystals are a potential topic to be introduced into curricula in future, we assessed the informally obtained knowledge of students who had finished secondary school education. The paper-pencil questionnaire comprising 31 items was completed by 448 first-year university students at the beginning of the academic year 2009/10. They were asked about general concepts related to the state of matter, a few general questions related to liquid crystals and a few more elaborate questions about their properties. The results show that 2/3 of students are not familiar with liquid crystals. In this paper the item analysis and the detailed analysis of the results with respect to conceptions of different groups of first year university students (pre-service science teachers, pre-service primary school teachers, etc.) are presented. According to the results of this study, the teaching unit was developed (see the presentation Ziherl *et al*., 2010).

Keywords: *liquid crystals, students' conceptions, knowledge self-assessment, misconceptions.*

INTRODUCTION

One of the main problems in Europe is the lack of motivation for science and technology studies. The main problem is that usually the school chemistry and physics studies have little in common with students' experiences from everyday life. A possible way to motivate them is the introduction of contexts in which chemical and physical concepts are connected to the daily life of students. These context-based approaches aim to bring the students' learning closer to their own experiences, and share characteristics that make the learning of science more meaningful (Bulte *et al*., 2004).

Liquid crystals are relatively exotic materials that have the properties of liquid and crystal at the same time. They have interesting properties for applications and therefore they are widely used in displays, phones, laptops, mp4 players etc. Liquid crystals can be a rich source of context-based units in chemistry and physics (Brown, 1983; Wright, 1973).

Unfortunately today, liquid crystals are not even mentioned within the chemistry or the physics curricula in secondary schools. Even though they do not learn about them in the school, we expected that students would obtain some knowledge about them through informal education. Therefore, the main purpose of the study was to assess secondary school students' conceptions about the liquid crystals.

The research questions (RQ) that were considered in our study were:

RQ1: What was the students' achievement on the LCQ regarding their self-assessed knowledge about liquid crystals?

RQ2: What is students' conception about liquid crystals after finishing secondary education?

RQ3: Do students who study chemistry or physics, other natural sciences or social sciences differ in their conceptions about liquid crystals?

METHOD AND RESULTS

448 first year university students (they have recently finished their higher secondary education) participated in the study. 15 % of students study chemistry or physics, 16.5 % other natural sciences (biology, home economics, computer science, and mathematics) or technology subjects and 68.5 % of students studied social sciences. Students come from mixed socio-economic backgrounds.

A 31-item paper-pencil questionnaire (LCQ) about liquid crystals was applied in October 2009. The questionnaire consisted of three parts: the general part, the motivation part and the part related to liquid crystals with 17 items. The part concerning liquid crystals had 4 general questions related to the soft matter, 4 questions of general knowledge about liquid crystals and 9 questions related to deeper understanding of phenomena related to them.

RQ1: About two thirds of students have not heard about liquid crystals yet, and 73 % of students think that their knowledge about liquid crystals is negligible. The independent samples t-test shows that there is a significant difference in achievement on item, that evaluate students' conceptions about liquid crystals between students who self-assess their knowledge about liquid crystals as moderate ($M = 4.9$; $SD = 2.5$) or negligible ($M = 3.2$; $SD = 2.4$); ($t(435) = 6.52$; $p \leq 0.000$)

RQ2: The results show that students' conceptions about liquid crystals are weak. Students achieve only 3.6 points ($SD = 2.6$) on average out of 17 on the items testing their conception of liquid crystals.

RQ3: One way analysis of variance (ANOVA) shows that there is no significant difference between students who study chemistry or physics ($M = 3{,}66$; $SD = 2{,}502$), other natural sciences ($M = 3{,}88$; $SD = 3{,}088$) or social sciences ($M = 3{,}51$; $SD = 2{,}420$) in their knowledge about liquid crystals ($F(2, 445) = 0.65$; $p = 0.521$).

CONCLUSION

Despite the fact that the liquid crystals are common in everyday life, students have very limited knowledge about them. Most of the students who had heard about liquid crystals relate them to displays. Our results show that further work on this interdisciplinary topic, which should be carefully included into physics and chemistry curricula, is worth the effort (see abstract Ziherl *et al*., 2010).

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SMOKING DURING PREGNANCY: STUDENT´S JUSTIFICATIONS AFTER A PROBLEM-BASED LEARNING MODULE ON RESPIRATORY AND CIRCULATORY SYSTEMS

Franco Pirrami

University of Camerino - Italy

franco.pirrami@unicam.it

Agnaldo Arroio

University of São Paulo - Brazil

agnaldoarroio@yahoo.com

ABSTRACT

The aim of this study is to investigate how students give scientific based justifications after having experienced a problem-based learning activity regarding the respiratory and the circulatory systems. The scenario used was related to smoking consequences. Along six weeks, students in three classes of Italian compulsory secondary schools used the problem-based learning approach. After five months they were asked to write a text to give suggestions regarding a behaviour related to cigarettes smoking. Results show that the majority of students use anatomy or physiology concepts to justify their suggestions.

Keywords: *health education, secondary school, problem-based learning, justification.*

INTRODUCTION

Health Education is a life-long process that helps people to make informed choices towards healthy habits (Katz & Peberdy, 1998).

Adolescence is a critical period for engaging the population in health as new behaviours are laid down and influence lifelong health (Viner & Barker, 2005). Sensation seeking makes adolescents more vulnerable to nicotine, alcohol and drugs addiction (Martin *et al.*, 2002).

Knowledge of the physiological processes and awareness of the consequences that behaviours have on one’s own health might encourage people to avoid unhealthy habits.

As I don’t consider an effective educational strategy just preaching what is good or not, I chose to use Problem-based learning (PBL) approach (Barrows, 1998). Thus, starting with a scenario, students could get more interested in exploring the topic, in researching about it, and in discovering consequences of unhealthy habits by themselves.

Such an approach based on problems/scenarios drawn form real life is also at the base of the development of students’ justification and argumentation skills (Jiménez-Aleixandre, 2008).

OBJECTIVE

The aim of this work is to investigate how students justify their suggestions about smoking effects after having dealt with a PBL approach regarding respiratory and circulatory systems.

METHODS

TIMING, PARTICIPANTS, AND ACTIVITIES

During November and December 2008, 64 students in three classes of Italian compulsory secondary schools (15 to 16 years old) experienced a PBL approach to deal with circulatory and respiratory systems. The module lasted six weeks, with two hours lesson per week.

At the beginning and during the module inputs related with smoking components and effects were given to students with the aim of promoting a discussion among them. The discussions were never preceded by teaching scientific contents and students were induced to search for information regarding anatomy and physiology of the respiratory and circulatory systems which could explain smoking consequences. Information was then presented and collaboratively elaborated with the tutor's contribution, first, in small groups and, then, at the class level.

In May 2009 students were asked to write a text in which they had to give suggestions to a friend who was a pregnant smoker.

DATA ANALYSIS

The evaluation of justifications given by students was done establishing four categories and three sub-categories that are shown in tables 1 and 2.

Table 1. Categories used to classified justifications

1	No explanations are given about how substances pass from the mother to the foetus
2	Explain that substances pass with/through blood but do not use any other anatomical or physiological concept
3	Explain the passage of substances from the mother to the foetus using one or more concepts on anatomy of the respiratory and/or circulatory systems
4	Explain the passage of substances from the mother to the foetus using one or more concepts on physiology of the respiratory and/or circulatory systems

Table 2. Sub-categories used to classified justifications

A	Substances and consequences are mentioned
B	Only substances, but no related effects are mentioned
C	Substances are not mentioned

RESULTS

One third of the students give justifications according to category 4, one third according to category 3 and the remaining are equally divided between category 1 and 2. Students who gave justifications using anatomy and physiology concepts also mentioned smoking components and effects (sub-category A) more than students who gave simpler or no justifications. Some examples of answers are given below.

4.A - "…substances pass from the mother to the foetus through the blood… Carbon monoxide bind with haemoglobin with an irreversible bond and this prevent the bond between oxygen and haemoglobin. This leads to a lower oxygenation of tissues and can cause several problems, as underdevelopment of the foetus… Another substance is nicotine which is the cause of addiction…".

3.A – "…smoke components, as carbon monoxide, go through the pharynx and the bronchioles and they reach the alveolus where they pass into the blood... The mother exchange substances with the foetus via the placenta, so substances contained in the blood reach the foetus… smoke components can induce malformation and cancer in the foetus…".

2.B – "…the foetus is in connection with the mother and substances, as carbon monoxide and nicotine, pass through blood form the mother to the foetus.".

1.C – "…if you smoke is like if your child were smoking, as the substances that you breath-in reach the foetus and produce several damages to his health.".

CONCLUSIONS

When students are stimulated with a real life problem they can acquire knowledge that is retained at least for some months. Most of the students that have acquired scientific knowledge with a problem-based learning approach are able to use it to justify their claims.

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THE SOCIAL OBJECTIVES OF EDUCATIION IN VIEWS OF JASPERS AND THE ROLE OF VIRTUAL EDUCATION

Saeid Zarghami Hamrah

Department of philosophy
Tarbiat Moallem University

E-mail: zarghamii2005@yahoo.com

Mohammadreza Behrangi

IOSTE regional representative of Persian gulf countries
Tarbiat Moallem University

E-mail: behrangi_m_r@yahoo.com

ABSTRACT

In this paper the objectives of education in views of Jaspers and the role of virtual education in them was studied. Jaspers believes that educating learners as useful members of community means, on one hand, preparing them for future life and job provided by virtual education and on the other hand, it means reviving and fostering traditions of that society to learners through day to day life, manner of speaking and social encountering like contact with human character of a teacher. Therefore, the virtual education can not be replaced face to face education. Finally some applied implications have been mentioned.

Keywords: *Virtual education, Information Technology, Social objectives of education, Jaspers*

INTRODUCTION

With attention to the importance of education and its role in the whole of human life and destiny, it is necessary alongside virtual education technical development, the role and its consequences on the whole education process and human life will be investigated.

Thoughts and questions about the technology date back to Greek, but by development of new technologies in the nineteenth century, and enveloping it in the twentieth century, philosophical questions of this technologies also has been spread and philosophers such as Heidegger(1977),for instance, less or more have evaluated technology and information technology and its consequences. Among the philosophers who have studied new Technologies the role of existence philosophers is more prominent and fundamental.

On the other hand, Jaspers (1956, 1957, 1963 and 1969), one of the main representatives of the philosophy of existence, have some ideas as educational philosopher. In the present study his ideas regarding the education and the relationship of virtual education with that are investigated. It seems that, on the one hand, education has a kind of communicational and social nature. On the other hand, Jaspers considers that "being self" and "becoming self" to be possible only on the basis of communication (1969). Therefore, social objectives of education can be investigated from the view points of Jaspers. Based on this fact, first some of the social objectives of education are deduced with regard to the Jaspers views and the role of virtual education in the achievement of these objectives are studied.

RESULTS

In the study the relationship between the virtual education and some of the social objectives of education were examined from the view of Jaspers.

Jaspers makes difference between "community" and "society" and believes that educating learners as useful members of community means, on the one hand, preparing them for future life, job and on the other hand, it means awakening, preserving and fostering the traditions and the genuine historical culture and soul of that community in students through day to day life, manner of speaking and social encountering like face to face contact with human character of teacher that Jaspers (Graic, 2000) calls "existential relation". He claims that "being self" and "becoming self" is possible only based on such communication; communication with others, traditions, culture and history. Jaspers in his emphasis on the role of communication in human evolution, even in the lowest level of life which is the ordinary life, refers to the deaf kids that were considered as dull before the creation of the sign language, but by the creation of the sign language as a communication device, the inaccuracy of the theory and the role and significance of communication were revealed (1963). Furthermore and Like Kierkegaard, (Prosser and Ward, 2000) it seems that we can introduce authentic person in relation to authentic community: authentic community knows its past and depends to it and so people have opportunity to conscious about the past of their community and connect to it.

Virtual education in connection with the first aspect, (preparing students for future life and job), has provided abundant opportunities: Nowadays, the easy and fast access to the information has, has moderated the extensive need for it and also has helped in saving the time for gathering information and so has accelerated the process of scientific production. As the consequence, the quality of the material life has increased. Every day the learners witness the achievements of Information Technology such as freeing human from illnesses and enriching his life with learning, art, sport, and recreation. As an example, we can mention the extensive virtual education that has facilitated the learning of such scientific skills as driving and piloting.

But alongside these achievements, virtual education also has changed the life pattern of teachers and students. For example, they rather communicate face to face, for their informational and even social needs, communicate virtually such as chat and email. Spreading the process is a challenge for the second aspect, i.e. awakening, preserving and fostering the traditions and the genuine historical soul of that community in students.

CONCLUSIONS

So the educational systems should train the teachers who are representative of traditions and authentic historical culture of that specific community. It should also provide the context for interactions between the teacher and learners in the school and community in order to animate the community's traditions and culture in the students and supply the ground for preserving and growing them.

on the foundation of research findings and by accepting the priority of the question concerning technological paradigm than question concerning how reforming by using it some applied implications as follow up virtual education beside face to face education and emphasis on holistic view than unilateral one in using virtual education have been mentioned in conclusion part of this paper.

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INFORMATION AND COMMUNICATION COMPETENCE OF BIOLOGY TEACHER IN THE FACE OF SOCIAL AND EDUCATIONAL CHANGES

Katarzyna Potyrala

Pedagogical University of Cracow
Institute of Biology

potyrala@up.krakow.pl

Alicja Walosik

Pedagogical University of Cracow
Institute of Biology

alice@up.krakow.pl

ABSTRACT

Education must constantly be adapted to new needs. Educational tasks determine new styles of teachers' work and also their competences, showing that the effects of the course of didactic process depend on the teacher's awareness to a large extent, way of understanding of the school's reality and the students themselves. Currently the media are ever-present. Mass media and hypermedia shape new patterns and new values. In the article the attempt to answer the question: "What kind of biology teachers' competence are necessary in connection with the social changes?" is undertaken. The survey research among 45 biology teachers was conducted.

Keywords: *social changes, information, communication, teachers' competence*

RESEARCH METHODOLOGY

The following objectives have been specified: 1/ formulating general, theoretical assumptions of teaching training with use of different ways of communication, 2/ studying aspects related to functioning of the models of didactics communication and mediation as instruments for formulating metacognitive strategies in students. Research hypothese: In view of the social and educational changes the priority is defining a canon of new teachers' skills and deeper understanding philosophy of the reform. It means mainly: metacognitive competence and ability to use the dialogue ICT-aided strategies. 45 biology teachers participated in the survey research and in the attempts of modernizing educational process. One part of the research concerned the self-evaluation of creative and informative competence. Second one was connected with the analysis of the teachers' activities connected with the practical application of different form of communication (tasks) during ICT-aided biology postgraduate studies. The research was also connected with the analysis of the curriculum and teaching standards at university level.

RESULTS

The results put main attention on the fact that system of ICT-aided biology and environmental teachers' education is partly adapted to the requirements of information society. The realization of teaching aims partly need help of technology and cooperation, some part of teaching contents need only the ability of information gathering and communication understanding as a simple data transmission. The results confirm the authors, views that necessity of the changes is connected mainly with the fact that ICT and subject education has too small number of links and such skills as critical and alternative thinking aren't sufficiently educated with thought about their utilization in contemporary world of media and technology, permanent education and metacognition.

CONCLUSIONS

New canon of teachers' competence must take into account training needs, teachers' and students' individual learning style, strategies of dialogue, work in collaboration. It means preparing teachers to new role: facilitators of students' learning and mediators of different scientific problems. Teachers need pedagogical content knowledge on the role of ICT tools in the respective disciplines and how that influences how we formulate learning objectives (Louka & Constantinou, 2007).

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QUESTIONNAIRE AS A TOOL FOR EDUCATIONAL PROCESS EVALUATION IN THE AREA OF BIOTECHNOLOGY

Peter Raspor

University of Ljubljana, Biotechnical Faculty, Food Science and Technology Department, Chair of Biotechnology, Microbiology and Food Safety

Jamnikarjeva 101, 1000 Ljubljana, Slovenia

peter.raspor@bf.uni-lj.si

Maja Paš

University of Ljubljana, Biotechnical Faculty, Food Science and Technology Department, Chair of Biotechnology, Microbiology and Food Safety

Jamnikarjeva 101, 1000 Ljubljana, Slovenia

maja. pas@bf.uni-lj.si

ABSTRACT

In this contribution we present different types of questionnaires designed for evaluation of educational process of Biotechnology course, which had been performed within the study of Food science and technology at Biotechnical Faculty at University of Ljubljana for 20 years (from 1989 to 2009). Students' opinion regarding realization of that course was a useful tool for applying some improvements of educational process and furthermore, delivered a platform for later development of biotechnology studies.

Keywords: *biotechnology, education*, *questionnaire*

INTRODUCTION

Biotechnology is a very fast developing field in bio-technical and also in sociological dimension (*Raspor et al., 2000*). For that reason, biotechnology education is exposed to extremely fast and profound changes, which have to be followed by up to date courses which can deliver new knowledge and skills to students very fast after discoveries and their implementation to practice. This is one of the reasons why teaching methods and subjects have to be implemented regularly and fast to cope with changes in this field. Ignoring this fact, it would mean that out of date knowledge and skills will be delivered to students and practice will not accept them with sympathy and enthusiasm. Biotechnology study at University of Ljubljana started at postgraduate level in 1993/94 and continued at diploma level in 2003/04 (*Cedilnik et al., 2003*). In a meantime, majority of biotechnology education was going on through a basic course of Biotechnology within the study of Food science and technology at Biotechnical Faculty at University of Ljubljana, as it is also common at other European universities. Managing education success and teaching outcome is important tool among performance indicators in higher education. Some schools are focused chiefly on research outputs. They ignore the teaching function of universities. This paper outlines the development of a student evaluation instrument designed to measure the teaching performance of basic academic organisational units, which is at our university the Chair. The theory of teaching and learning that underlies the course experience questionnaires is described in continuation. The instrument's statistical qualities and its ability to discriminate intelligibly between different courses and topics are discussed in the context of education.

The principal conclusion reached in the last years is that the questioners offer a reliable, verifiable and useful means of determining the perceived teaching quality of academic units in systems of higher education that are based on combination of teaching models and teaching practices. There is always permanent question about purpose of the evaluation? It could be an evaluation of the quality of the educational product. This could be focused on the whole programme, a course, a module, a class (lecture, seminar, exercise, etc.) on one side or the performance of the programme providers like the academic staff, tutors, support staff, chair. Finally, the actual knowledge or experience of the students as partners in the process can be assessed as well as their experience, motivation and approach to learning. Our students had been constantly evaluated about their opinion regarding education in biotechnology. Their responses were a useful tool, which helped a lot not just in evaluation of course improvement, but also delivered platform for later development of regular studies in Biotechnology and offered possibilities for improvements of Bsc (*Raspor, 2006*) and Msc courses (*Raspor, 2007*). This approach was found out as good attitude for better teaching and higher success of knowledge and skills transfer.

METHODS

We developed a **special questionnaire**, which was applied for more then decade and gave an excellent overview about transformation of students' perception of Biotechnology knowledge and skills as well as teaching methods in this area. Since we also have regular evaluation with **official questionnaire**, which is performed yearly by Biotechnical Faculty, suitability of both questionnaires for that purpose can be easily compared. Official questionnaire is comprised from five questions mostly assessing teachers' or assistants' characteristics in following domains: Quality of lectures/exercises/seminars, Stimulation of discussion, Relation to students, Accessibility for help and discussion. Special questionnaire contains 22 questions that are considering following issues:

- the clarity of the stated educational aims and learning outcomes
- the realism of stated pre-requisites/prior knowledge
- the curriculum and its content - perceptions of relevance/usefulness
- the way in which the curriculum was presented or delivered
- the development of subject-specific skills
- the development of non-subject specific (personal and/or transferable) skills
- the appropriateness of the methods of assessment
- the appropriateness of the style of teaching and the performance of teacher
- the quality of feedback to the student on the performance of the student
- the motivation/attitudes of the student
- the educational challenge presented to the students
- the workload, how reasonable, how realistic
- the support available to students/course books/resources for independent learning
- the effort made by the student, and the take-up of support/guidance
- the overall experience of the student of the teaching and support for learning

RESULTS

The special questionnaire gives more information to teachers and assistants for improvements of the course at different levels: attitude, motivation, overlapping with other courses and already gained knowledge, as well as a relation between teacher and students. On the other hand, it is quite time-consuming. For that reason, we coined in recent years a

horizontal screening questionnaire, which is user-friendly for teacher and students. It takes much less time for responding and evaluation, however, it can not deliver the same quality of information. The official questionnaire gives some figures, which can not be easily correlated to the course, it's subject and realization mode.

CONCLUSIONS

One can conclude that special questionnaire is a more suitable tool as the official questionnaire. However, all questionnaires are useful tool for teacher because of students feedback, they are useful for students because they realize the importance of their attitude for gaining new knowledge and skills and it is important for chair (group), because it can help in developing new teaching tools to enhance knowledge transfer. We can also not ignore the fact that new technologies do not always follow traditional technical rules and for that reason communication of new achievements in the frame of public perception shall not be ignored.

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THE COMPLEX DYNAMIC OF THE LEARNING ACTIVITY

André Machado Rodrigues
University of São Paulo, Brazil
andremr@if.usp.br

Cristiano Rodrigues de Mattos
University of São Paulo, Brazil
mattos@if.usp.br

ABSTRACT

Individual's concept meanings development goes beyond a process that deals with the dynamics of internalization of relations among the elements of the living world, i.e. person's cultural-historic milieu. The internalization of concepts is associated with the attribution of words meanings, which are used in specific contexts. Understanding the mode persons become conscious of words meanings, allows comprehend, during formal teaching, how discursive interactions can contribute or not to learn the meanings of the words teacher would teach. In this work, through a theoretical investigation, we related the socio-cultural processes to the persons' cognitive changes. In order to deal with this problem we related Vigotski's internalization concept and Mortimer's conceptual profile model within Leontiev' Activity Theory. We understand that the teaching-learning process is composed by different structuring levels, whose hierarchies are defined by the degree of complexity of the dynamic interaction in the ZPD. This situation demands negotiations of meanings between peers that use their conceptual profile zones. In this sense, the proposed a model relating the mental representations –conceptual profiles – and the complexity of living world. Here the teaching-learning process is constituted by the articulation of the several levels of representation in a social interaction field of living activities.

Keywords: *Internalization, context, activity theory, conceptual profile*

INTRODUCTION

The concept of internalization has been pointed out in recent cultural-historic investigation approaches, mainly because it is a concept that relates subjects' external world to subject's internal processes, such as the development of superior mental functions. In this sense, understand internalization process is to understand the teaching-learning process, also in its formal or informal mode. Our discussion introduces the concept of internalization from the point of view of complex systems. Within this theoretical perspective, we can deal with internalization as a complex dynamic process, composed by interactions among several hierarchal levels that are retro-feeding. We start from a discussion about the relation between concept learning and context, trying to observe the dynamic aspects of the teaching-learning process. In this way we took as base Rodrigues and Mattos's (2007) extended versions of Mortimer's (1995) conceptual profile model. We present a learning model as a conceptual profile evolution process in the teaching-learning activity.

It seems obvious that to represent the complex dynamics of the world, the conceptual profile zones should have an associated complex dynamic that allows learning the continuous context changes to which subjects are submitted. It is necessary to consider that individuals evolve psychological and cognitively as a function of a learning process, through a dialectical interaction with his/her social-historical context (Vigotski, 2001).

In this work we propose a model to describe the process of conceptual profile zones evolution in the learning activity. We see the teaching-learning process as a composition of different structuring levels, whose hierarchies are defined by the degree of the complexity of the dynamic relation among the concepts that are internalized. This model helps us to mark a conceptual profile dynamics related to the profile zones, as well to the possible relations among different profiles. In this perspective, we associate the learning with the activity through the process of internalization and generalization (Leontiev, 1978).

FRAMEWORK

To deal with this assumption we use the Activity Theory framework (Leontiev, 1978). We correlated the mechanisms of evolution of the conceptual profile with aspects of the learning activity, using Rodrigues and Mattos (2007) learning orders as markers of the conceptual profile dynamic process.

To Leontiev (1978) the development of the conscience is a private internal activity generated by the dynamic of the human activity, and vice-versa. This process is mediated, at the same time, by the work instrument as well as by the society. All human activity has a motive, which has origin in the individual's (or group's) needs. The activity is composed by a set of actions performed by individuals (or sub-groups) that disjointedly does not lead directly to the possession of the needed object. The actions have specific ends that do not coincide, necessarily, with the motive of the activity, but jointly they constitute the activity. In short, the activity is composed by actions that are composed by operations. These aspects have the same structure therefore we should be able to distinguish, in the cognitive activity, actions from operations. The appropriation of a socially built content, whose meanings are expressed through words, is an interior activity. Then learning is characterized by the internal activity of appropriation of contents embodied with individual's sense. Leontiev (1978) considers that the appropriation of practical and cognitive human actions goes beyond the process denominated "internalization of external actions" (p. 184). These gradual transformations of what is external into internal, happens while students live in the activity. These transformations come from the need of human's knowledge acquisition and it is conditioned to the significations refraction through the prism of the widespread experience of the social practice. The refraction of the phenomena or concepts in its signification can be understood as learning in context.

Thus, there is an organization of actions and operations articulated in several hierarchical levels that, depending on the observed activity, can be interchanged, that means, actions can be seen as operations and vice-versa. More articulated compositions, of activities in actions and operations, reveals the complexity of the cognitive structures of representation and of the human activity.

THEORETICAL SYNTHESIS AND CONCLUSIONS

Our interest, from this theoretical framework perspective, is to understand the communication process in the teaching-learning process of scientific concepts in Science classrooms. This hierarchical organization can be exposed in the Newton's second law problem solving activity. To understand how Newton's 2^{nd} law formula and its Physics content become an operation (or action) in a problem solving activity, it is necessary to decompose the activity in elementary actions and operations, its basic structure (conceptual profile hierarchies). The same rationale could be applied to the hierarchies of the Physics concepts: acceleration, mass and force that become operations in the problem solving activity. Each one of these concepts has countless inexplicit hierarchical levels of operations (notions of time, space, displacement, inertia, vectors etc.). Besides considering each element isolated, we must consider their composition, the complete expression that, to superior hierarchical levels, stops being an action to become an unconscious operation in the resolution of more complex problems, including more complex conceptual profile such as “problem”, “solving” or “learning activity”.

The activity, the actions and the operations that students and teachers carry out converge in the construction of a context where the educational activity happens. It is where the teacher can contribute, as a more capable peer, to the students’ scientific concepts formation, negotiating meanings and driving then towards an appropriate context, which motivates the achievement of the learning activity.

It is fundamental the idea that students’ learning is a vital process that happens during their whole life, including science and technology immersed in socio-political environment where values are confronted, even at the school situation. The internalization of specific conceptual profiles zones in the school life is a stage of the development process of that concept (Vigotski, 2001). Therefore, we can attribute to the school the role of promoting the consciousness that the learning process lasts for the entire lifetime. In this sense learning and development represent the dynamic of the conceptual profile in all its dimensions - epistemological, ontological and axiological (Rodrigues & Mattos, 2007).

It is very important to know in which learning order the student is, regarding a specific concept, so the teacher can establish pedagogic actions that make students conscious of the meanings’ limit of his/her utterances in other contexts as quotidian contexts. For this reason, it is important that the teacher be aware of these stages and understands that it is essential to clearly define the context where the concept he is willing to teach, have the appropriated meaning. This action is part of a social interaction state (ZDP) and a teacher/student cognitive state –conceptual profiles– that belongs to the context meaning negotiation.

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PATTERNS IN PUPIL BEHAVIOUR WHEN USING CHEMISTRY SIMULATIONS: INTENDED DESIGN AND REALITY OF ACTION

Susan Rodrigues

University of Dundee

s.roddrigues@dundee.ac.uk

ABSTRACT

This paper reports on pupil engagement with simulations that are indicative of those commonly available to school science: practical experiments or simulations depicting microscopic chemical interactions. The project included a phase involving 14-16 year old pupils and used a retrospective accounts methodology (Clarke, 1998) to access their explanations. The second phase involved monitoring online behaviour while pupils aged 12 to tertiary aged students used the simulations. A digital record of their pathway data documenting their behaviour was obtained and analysed. This paper reports on the nature of the behaviour observed and offers explanations for particular actions.

Keywords: *Simulations, chemistry, school and tertiary students.*

INTRODUCTION

Rodrigues (2009) has documented the potential of various computer-based technologies for science education. Much of this potential is guided by a belief in the power of computer based technologies to motivate pupils and is guided by a suggestion that goal orientation, interactivity and feedback empowers pupils and produces enhanced learning outcomes (Leach, and Moon, 2000; Löhner, Van Jooligen and Savelsbergh, 2003; Stief and Wilensky 2003; Ardac and Akaygun, 2004; Lagowski, 2005).

METHODOLOGY

There are two phases to this project. The first involved a small cohort using simulations and a retrospective methodology being deployed. In the first phase the pupils were filmed as they used the simulations, these records were played back to them and they were asked to explain their documented behaviour. The second phased involved pupils from several schools and students doing chemistry in one tertiary institution. This cohort had their online behaviour tracked and recorded. We then analysed the patterns of behaviour observed and recorded.

SIMULATIONS

The project selected simulations from this website that were representative of many commonly found types of simulations used in science lessons in schools. Two types of simulation, typical of many commercial products, in terms of their appearance, their quality and their purpose, were impressive from a teaching perspective. They reflect realistic experiments, they provide opportunities to conduct experiments without incurring costs for equipment or resources, and they allow for multiple repeat experiments. From a teaching perspective the microscopic representations provide an opportunity to animate what has until recently only been shown as static models in textbooks, or as ball and stick models in classroom demonstrations. On the website, some of the simulation also have tutorial worksheets. However, for the purpose of this project, the simulations were used without accompanying worksheets. In this paper we present findings that pertain to the titration simulation. Acid base titrations are common experiments undertaken in school chemistry (Sheppard, 20006).

FINDINGS

There were several interesting findings with regard to perception of ease and reality of recorded behaviour. This paper discusses some of these findings.

PHASE 1

Though most of the pupils were unable to carry out the titration because they relied on their prior knowledge and discounted the instructions available, those who had undertaken titrations in the past, were able to clearly explain the process, their intentions and their science understanding for the reaction. This would suggest that the pupils' information processing skills rather than their chemistry was being tested by the simulation.

PHASE 2

Our sample suggests that on the whole the titration simulation was seen to be as interesting (64%) as a computer game. Of the thirteen 18 year olds (university students) in the sample only three (23%) thought the metal simulation was not as interesting as a computer game. In contrast, 40% of the 12-13 year olds, (6 of the sample of 15), 60% of the 14-15 year olds (9 of the sample of 15) and 46% of the 16-17 year olds (5 of the sample of 11) thought the simulation was not as interesting as the computer game. So, given that the University students were all studying chemistry through choice, perhaps it was the subject matter rather than the simulation that rendered it interesting. However, this is purely conjecture as we did not ask for their reasons for interest. The data from our phase 2 sample also suggests that the titration simulation was perceived to be easy (82%). While one of the eighteen year olds and none of the 12 –13 year olds thought the simulation was not easy. Overall a high percentage of students found the simulation easy and only 3% did not think the titration simulation was easy. However, our preliminary analysis suggests that student perception of ease and interest was not necessarily found in their performance as they used the simulation and in their responses to questions based on their understanding.

CONCLUSION

The findings from this project suggest that e-assessment involving the use of multimedia or symbolic representation in science education will have to take great care if it is to ensure that what it is assessing is the pupil's science capability and not information processing skills, that rely on shared symbol identification or on the ability to follow the designers' logic of instructions. We must ensure that symbolic representations used in multimedia software does not assume that the pupils will assign meanings to symbols as intended by the designers.

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THE INCORPORATION OF ETHICS INTO A SCIENCE CLASSROOM

Washirasorn Saengsuwan

Science Education Center
Srinakharinwirot University

washi15@mwit.ac.th

Manat Boonprakob

Behavior Science Research Institute
Srinakharinwirot University

manatboo@swu.ac.th

Somson Wongyounoi

Educational and Psychological Test Bureau
Srinakharinwirot University

somson@swu.ac.th

Sirinoot Teanrungroj

Computer Center
Srinakharinwirot University

sirinoot@swu.ac.th

ABSTRACT

The purpose of this study was to implement the preliminary findings from a study entitled "Survey of Teachers' and Students' Opinions on Learning Ethics in a Science Classroom" to an actual science classroom. The preliminary research showed that 37.9 percent of students rated their level of understanding of ethics in science as high or very high. In addition, 66.3 percent thought that they are interested in studying ethics in science. Additionally, hybrid learning which is the combination of face-to-face and web-based learning can be an appropriate pedagogical method of learning ethics in science. This study is a mixed method research. Pre-and post-test, questionnaire and focus group interview were used. The sample group was 24 (9 females and 15 males) grade 10 science students from Mahidol Wittayanusorn School in Thailand. Students' awareness and understanding on ethics in science, thinking skills, and communicative skill were assessed. Also, hybrid instruction was evaluated. It was found that students' awareness and understanding were increased as well as thinking and communicative skills. In addition, students reported that they were satisfied with the hybrid learning they experienced, even though some improvement is needed. These findings will eventually be offered for use of other schools in Thailand.

Keywords: *Ethics in science, Hybrid Learning*

INTRODUCTION

Ethics is concerned with what is right or wrong, good or bad, fair or unfair, responsible or irresponsible, obligatory or permissible, praiseworthy or blameworthy. It is associated with guilt, shame, indignation, resentment, empathy, compassion, and care ("Chapter 2", 2006). The Ven. Phra Dhammapitaka (Bhikkhu P. A. Payutto) (1995), stated ethics is a good way of life. In this study, ethics is based on 12 principles of scientific ethics, proposed and defended by David B. Resnik (1998) which applies to different aspects of the research process in order to not violate commonly accepted moral standards and to promote the advancement of scientific goals.

Blended learning or hybrid learning is defined as learning that combines online and face-to-face approaches; blended learning enables classroom teachers to increase student learning opportunities beyond the school day and school year (Pape, 2006). An experimental project at the University of British Columbia showed that a mixed-mode university course, combining online learning and face-to-face meetings can encourage students to formulate and express their own ideas more than would be the case in traditional classrooms (Breton, et al., 2005). In addition, a study that has investigated and compared students in face-to-face classes, web-based classes, and hybrid courses which combine both methods showed that hybrid courses have the highest success rate (Brown, 2001).

This study was the second phase of the research study which focuses on implementing the preliminary findings of "Survey of Teachers' and Students' Opinions on Learning Ethics in a Science Classroom" to an actual science classroom. The main purposes of this study were 1) to develop and promote students' awareness and understanding on scientific ethics issues, concepts, and principles. 2) to promote students' thinking skills and communicative skill. 3) to develop and evaluate hybrid learning.

METHODS

The sample group was 24 science students who took a class of fundamental chemistry, 1st semester, 2009 at Mahidol Wittayanusorn School which has the goal of providing world class education at upper secondary levels (Grade 10 – 12) for exceptionally gifted and talented students in science, mathematics and technology so that they will have all the prerequisites necessary to become avid lifelong learners, researchers and innovators. The curriculum also strives to be well balanced and therefore promotes physical fitness as well as humanistic moral and ethical values. Being proud of their Thai identity, the students will be dedicated to national development, and environmental protection while at the same time having a congenial attitude towards others both in Thailand and the world at large ("Mahidol", 2006).
The chemistry course consists of three main chapters which are atomic structure, chemical bonding and periodic table. Ethics in science was incorporated throughout the entire semester. Students were exposed to scientific ethics through the following activities; discussion, ethics quotes, sub-examination, case analysis, oral presentation, experiments, painting and drawing, classroom atmosphere, and so on. This study is a mixed method research. Pre-and-post test, questionnaire and focus group interview were used to obtain data.

RESULTS

From pre-and post-test, it found that after learning ethics in science, students had more understanding in ethical concept and principles than before. There were statistically significant differences in means of the score of pre-and-post test (P=0.05).
According to the focus group interview, for the question "Should this kind of class be the model for other science classes? A student responded to this question that "Yes, it was fruitful, but only our class was be able to get a chance to learn it, not the others. Therefore, it should be offered for use to the other general science classes or it could be in an additional science classes or even in science club". In addition, they thought that all science students should learn scientific ethics because it is very important to get to know the ethical principles and then make use in scientific endeavor. Students agreed that learning ethics in science help enhance analytical, creative and practical thinking skills as well as communicative skill. More importantly, it made them becoming more aware of the need of scientific ethics.

CONCLUSIONS

It was found that students' awareness and understanding were increased as well as thinking and communicative skills. In addition, students were satisfied with use of hybrid learning, even though some improvement is needed. These findings will eventually be offered for use of other schools in Thailand.

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LEARNING SOCIO-CULTURAL & HUMAN VALUES CONSIDRING KNOWLEDGE MANAGEMENT PRINCIPLES

Leila Safaeifakhri

Science & Research Islamic Azad
University Unit
Department of Educational Administration.

leila.safaee@gmail.com

Mohammadreza Behrangi

Tarbiat Moallem University
Tehran-Iran

behrangimr@yahoo.com

ABSTRACT

This paper demonstrates that learning socio-cultural & human values could be taken place through eclectically use of knowledge management principles and role playing, jurisprudential inquiry, participative and personal models of teaching. The principles with the models are supportive and together enhance instructional and nurturing effects on students learning and academic achievement in the first grade high school physics. Findings of this semi-experimental research with two control and experimental groups using pre and post test, SPSS and Java soft-ware demonstrate significant t value regarding academic achievement and socio-cultural & human values. The findings confirm the usefulness of the approach in teaching.

Keywords: *knowledge management principles, teaching & learning models, socio-culture & human values*

INTRODUCTION

How education could be responsive to the trends and challenges of socio-cultural and human values have become a major concern in the contemporary societies. The school reform towards new paradigm is one important worldwide initiative to promote school socio- cultural & human values, knowledge, self- initiative and autonomy for enhancing effectiveness and educational quality.

The Teaching & learning models that are used in the prepared scenario of teaching physics to the first grade high school students encompasses learning processes with the full range of nurturing and instructive effects on students' socio- cultural & human values which should be encountered in school settings. According to what Sallis and Jones (2002) define uses of the principles of knowledge management, the scenario of this research that works as an independent variable is made upon concepts and principles of knowledge in managing individual and group of students learning. The scenario of teaching also makes use of appropriate means and technology, students management in the class, their knowledge, their social interactions in performing tasks, their decision making and the way that information flows in the process of learning. As Davenport and Prusak (2000) state knowledge is a fluid mix of framed experiences, values, contextual information and expert insight that provides a framework for evaluating and incorporating new experiences and information. Not surprisingly, much of literature explores corporate applications of knowledge management including: different conceptions of organizational and personal knowledge; strategies for managing knowledge (Nonaka et al., 2001); and case studies of the impact of knowledge management on organizational success (Kreiner, 2002).

While one would suppose that educational organizations are relatively knowledge-intense organizations, there has been little discussion of knowledge management as a strategy for improving organizational practice, program implementation and teaching and learning within education (Fullan, 2001). At the moment, there is a lack of discussion within education of the potential of scaling-up these opportunities to create more systematic and systemic strategies for codifying and cataloguing knowledge and improving teaching and learning outcomes in schools (Fullan, M. ,2001).

METHODS

This semi-experimental study with two control and experimental groups is a description of teachers' approaches on applying knowledge management principles together with models of teaching for promoting students' socio-culture & human values.

RESULTS

Table 1 shows components of knowledge management in use of teaching and learning and the statistics organized through data acquired from the research questionnaire**.**

Table 1- Teachers' approaches to K.M. model for teaching & learning models

Component	Mean	Df	Std. Error Mean	Std. Deviation	T	Significance level
Creating Knowledge	3/37	83	0/05	0/48	16/61	0/01
Sharing Knowledge	3/21	83	0/07	0/69	9/43	0/01
Organizing Knowledge	3/07	83	0/07	0/69	7/53	0/01
Utilizing Knowledge	3/45	83	0/06	0/63	13/75	0/01
Assessing Knowledge	3/10	83	0/07	0/70	9/86	0/01

Table 2- Group statistics on academic achievement (control & experimental)

Groups	Mean	Std. Deviation	df	T value	Significance level
Control group	2/40	1/11	48	0/11	0/01
Experimental group	2/36	1/28			

CONCLUSION

From table 2 one could conclude that there is a significant mean difference between control and experimental groups which secures the generalization of implementing the approach for teaching other subjects. More statistical evidence on the size effects of this approach on students' socio-cultural and human values needs to be explained in full-paper..

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INCREASING ACCESS TO HIGHER EDUCATION: MULTICULTURAL EVALUATION

Irit Sasson

Department of Education in Tel-Hai Academic College,
Upper Galilee, 12210, Israel

iritsa@adm.telhai.ac.il

ABSTRACT

Accessibility Program for Higher-Education is a regional project that aimed at strengthening the potential of high-school students, and increasing the number of students that pursue higher education with emphasis on science domains. This research investigated students' attitudes (N=151) to science, self-efficacy, and exposure-rate to academic world before and after attending the accessibility program. Comparison was done between Jew and Arab students. No significant differences between Jew and Arab students were found in self-efficacy and general attitudes to science in the pre questionnaires. Nevertheless, Arab students declared significant higher interest in chemistry, computer-science and biotechnology in respect to the Jew students.

Keywords: Higher-Education, attitudes, science, self-efficacy

INTRODUCTION

The gaps between the periphery and the center in Israel are growing larger. These gaps are due to economic differences and mostly as a result of opportunities available. As opposed to their peers in the center of the country, many potential students in the periphery do not seek for academic education. Higher education must be offered to everyone and talent must be nurtured. The future of a society is dependent on educational excellence for all. Accessibility to higher education in Israel is particularly low among Arab students, only about 11% of all undergraduate students (Yogev, 2000). Perna (2002) concluded that pre-college programs can have a significant impact on the academic preparation and college enrollment of students from groups that have been under-represented in higher education. The basic requirement for Higher Education institute in Israel is an Israeli matriculation certificate, therefore initial gaps among different ethnic groups initiate during the high-school educational system. Major efforts for increasing access to higher education should be specified to high-school students.

Significant concerns have been raised over the last decade about lack of science interest and poor science achievement among high-school students in Israel. This tendency is stressed among Jew students. Science achievement was linked more closely to science attitudes than to aptitude among junior-high-school students (Houtz, 1995) and to self-efficacy (Martin, 2001). Self-efficacy is students’ belief and confidence in their ability to understand or to do well in their academic work, to meet challenges they face, and to perform to the best of their ability. Nevertheless, the value of academic science enrichment programs for improving science motivation and confidence and therefore increasing the accessibility to higher education is far less clear.

The Accessibility Project for Higher-Education at Tel-Hai Academic College, located at the most north region of the country, is a unique program aimed at strengthening the potential of high-school students, and increasing the number of students that pursue higher education.

The educational goals of the project are: to construct a natural educational continuity between high school and higher-education; to prepare students for higher education, with an emphasis on contexts and educational strategies in science and mathematics; and to expose students to hands-on laboratory work and computerized learning environments that are not available at local schools. Curriculum development is based on the constructivist approach which views learning as an active process that constructs meanings in the learners' minds (Rosenfeld & Rosenfeld, 2006). Special bilingual supplementary assistance is provided to overcome language difficulties among Arab students (partial translation of the learning resources that is reduced gradually during the program and a support by Arab undergraduate students).

METHODS

151 high-school students (65 Jews and 86 Arabs) aged 14-15 participated in the project. The purpose of this research is to investigate students' attitudes to science, self-efficacy, and exposure-rate to academic world before and after attending the accessibility program. All participants received pre and post questionnaires.

RESULTS

Table 1 presents results of analyzing the pre questionnaires.

Table 1: Students' results- Pre-Questionnaire; N=151

n.s= no significant

Category	Jew Students N=65		Arab Students N=86		t Test
	Mean (Max=5, Min=1)	S.D.	Mean (Max=5, Min=1)	S.D.	
General Attitudes to science	3.70	1.07	4.00	1.12	n.s
Self-efficacy	3.83	0.89	4.06	1.07	n.s
Exposure-rate to academic world	2.84	1.20	3.04	1.41	n.s
Interest in chemistry	3.15	1.26	4.31	1.01	$t=2.136; P<0.04$
Interest in physics	2.97	1.08	4.25	1.29	n.s
Interest in computer science	3.46	1.35	4.06	1.06	$t=2.289; p<0.03$
Interest in biotechnology	3.15	1.15	4.13	0.63	$t=2.278; p<0.03$
Interest in Mathematics	3.35	1.34	4.26	1.27	n.s

CONCLUSION

Initial results revealed no significant differences between Jew and Arab students in self-efficacy and general attitudes to science in the pre questionnaires. Nevertheless, Arab students declared significant higher interest in chemistry, computer-science and biotechnology in respect to the Jew students. The research is still under investigation in order to explore the program effects on high-school students.

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ASSESSING PRE-SERVICE SCIENCE AND MATHEMATICS TEACHERS ENVIRONMENTAL LITERACY IN TURKEY

Elif Selcan Kutucu	Betul Ekiz	Huseyin Akkus
Yuzuncu Yil University	Yuzuncu Yil University	Gazi University
kselcan@metu.edu.tr	ebetul@metu.edu.tr	akkus@gazi.edu.tr

ABSTRACT

The primary purpose of this study is to describe opinions of pre-service science and mathematics teachers' environmental knowledge, environmental attitude, environmental uses and environmental concern. Secondary purpose of the study is to investigate the correlation between these constructs. This study was conducted with 167 pre-service science and mathematics teachers by using environmental literacy questionnaire. Results of the study revealed that participants have inadequate knowledge about the environmental issues and they generally have a positive attitude towards environmental issues. Also there is a low positive correlation between the constructs i) knowledge and attitude ii) attitude and behavior iii) attitude and concern.

Keywords: *Environmental literacy, pre-service teachers*

INTRODUCTION

Because of the rapid development of the countries, industrialization increase across the world. If the essential importance is not given to the environment, inevitable hazardous conditions will occur. The role of the teachers is important to develop consciousness about the environment and so it is important to educate the pre service teachers about the environment. What they know and how they behave about the environmental issues has become an important issue. In Turkey little research has been done about the issue of pre-service teachers' environmental literacy. (Tuncer et al., 2009)

The purpose of this study is to examine the opinions of the pre service teachers about the components of the environmental literacy; environmental knowledge, attitude, concern and behavior and to reveal the correlation between these constructs. The environmental literacy questionnaire is used in the study and the study was carried out during the fall semester of 2009. Sample of this study constituted 167 pre-service science and mathematics teachers from a public university in Ankara.

METHOD

In this study, the survey data was statistically analyzed using frequency distributions and zero-order correlation. The research was conducted using an environmental literacy questionnaire. The questionnaire is composed of close ended questions and four components such as knowledge (11 items), attitudes (10 items), uses (19 items) and concerns (9 items). The knowledge component of questionnaire is composed of multiple choice items to assess pre-service teachers' knowledge about current environmental issues and it was developed by National Environmental Educational and Training Foundation

(NEEFT) and Roper. The other three components are regarding pre-service teachers' environmental attitudes, uses and concerns using five Likert-type scales. The instrument was originally developed in English and, translated and adapted into Turkish. The internal consistency of the knowledge, attitudes, uses, and concerns dimensions were found to be 0.88, 0.64, 0.80, 0.88, using Cronbach alpha respectively (Tuncer et al., 2009). In our study, the internal consistency of the knowledge, attitudes, uses, and concern components were found to be .44, .43, .70, .72. using Cronbach alpha respectively. This study was carried out during the fall semester of 2009. This study was conducted with 167 pre-service teachers (124 female, 43 male) in secondary science and mathematics department in a public university in Turkey.

RESULTS AND CONCLUSION

The frequency distributions of responses to the survey items were analyzed for pre-service teachers' level of environmental knowledge, attitude, uses and concern. Furthermore, the relationship is examined among the components of environmental literacy questionnaire. In environmental knowledge test, most of the pre-service teachers (91.6%) answered correctly the items related with definition of biodiversity and the industrial discharges are major sources for surface water pollution. The environmental knowledge item with least correct responses (24.6%) were interested in motor vehicles as the largest contributor of carbon monoxide whereas surprisingly more than 73% of the pre-service teachers answered incorrectly stated factories and businesses are the main source of carbon monoxide. The majority (38.3%) of respondents answered 'I don't know' for the knowledge item concerned storage of nuclear waste. NEEFT and Roper (2005) calculated letter grades based on percentage of respondents correct answer determining that cumulative scores of higher than 70% were acceptable levels of environmental knowledge. In our study, 37.2 percent of pre-service teachers received passing grade according to NEEFT and Roper's grading scale (see Table 1). In the attitude scale, most of the respondents (97.7%) agree with the item 'plants and animals have as much right as humans to exist.' On the other hand, a large percent of respondents disagree (71.8%) with the item 'the so-called ecological crisis facing humankind has been greatly exaggerated'. Per-service were also examined in terms of environmental uses and the results showed that most of the pre-service teacher seem aware of individual responsibility, the importance of environmental issues and, the role and the importance of interaction between environment and humans as well as they seem interested with the solutions of the environmental problems. In the concern dimension of the survey, according to the analysis per service teachers aren't very concerned about many environmental issues except poor drinking water quality (65.9%) and indoor air pollution(59.9%). We examined the relationship between pre-service teachers' environmental knowledge, attitudes uses and concerns. The results indicate that respondents' environmental attitudes have small but positive relationship between their perceptions of environmental use. (r= 0.28). The relationship between respondents' knowledge and environmental use small but significant (r=0.25). Similarly, it was found small but significant relationship between respondents' environmental concern and uses (r= 0.27).

Table 1. Pre- service teachers' aggregate scores for environmental knowledge items

Number of questions answered correctly	Score percentage range	Percent of respondents per score	Cumulative percentage of respondents	Adequacy of score
10 or more	90-100 %	7.8	7.8	Adequate
9	80-89%	8.4	16.2	Adequate
8	70-79%	21.0	37.2	Adequate
7	60-69%	16.2	53.4	Inadequate
6 or fewer	59% or less	46.8	100.0	Inadequate

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A FRAMEWORK FOR SCIENCE TEACHER PROFESSIONAL DEVELOPMENT TO SUSTAIN EFFECTIVE TEACHING PRACTICES

Hae-Ae Seo

Pusan National University

haseo@pusan.ac.kr

Jeong-Woo Son

Gyeongsang National University

cnbe@gnu.ac.kr

Bong-Woo Lee

Dankook University

peak@dankook.ac.kr

Young-Min Kim

Pusan National University

minkiyo@pusan.ac.kr

Myeong-Kyung Shin

Gyeongin National University of Education

mkshin@ginue.ac.kr

ABSTRACT

Programs for the professional development of teachers are essential mechanisms for sustaining teaching ability throughout a career. This study conducted in depth interviews with 30 science teachers about their experiences in current programs. The results indicated a lack of relevant content in the material that is currently provided, and a program structure which is insufficient to address the needs of individual teachers as they continue to grow professionally. The framework that this study proposes consists of seven stages which allow teachers to continue learning and improving based on their experience level and individual needs.

Keywords: *science teachers, professional development, framework*

INTRODUCTION

Teacher professional development programs are an essential mechanism of quality education because teachers who continually improve and build on their skills are better educators. These programs should inform teachers of innovative and effective teaching practices, but also must challenge each teacher based on their individual needs and career development. Several studies (Desimone, et al., 2002; Penuel, et al., 2007) have examined the effectiveness of these programs based on their overall structure, program content, teacher involvement and participation, and the implementation of acquired skills. Additional studies (Mamlok-Naaman, Hofstein, & Penick, 2007; Yager, 2005) developed alternative approaches for implementing teacher programs that were designed to more clearly represent the reform agenda. However, these studies seem to overlook the importance of addressing the different stages of professional development within the teaching community.

The educational needs of specific teachers must be addressed if professional development programs are to be effective. Their career stage, individual ability, educational level, and professional responsibilities must be taken into consideration. The most effective way to address the varying needs of teachers is through the implementation of a professional development program structure that consists of multiple stages, with content that is relevant to the needs of the teachers within each category.

There are several models that describe the various stages of professional development. For instance, Huberman (1989) defines five career stages consisting of; career entry (1~3 yrs), stabilization (4~6), the divergent period (7~18), the second divergent period (19~30) and disengagement (41~). Some professional development programs for new teachers focus on teacher retention during a period when a high percentage of teachers leave the profession. This is an example of a development program that targets the specific needs of teachers based on their career stage. Other professional development programs have adopted individual school-based mentoring as a strategy for promoting the exchange of skills and knowledge between teachers with different levels of experience. Many countries, including England and Germany (Hobson, et al., 2009; Jones, 2001), have utilized this type of mentoring program and have seen positive results.

Although these types of studies have received much attention internationally, they have gone largely unnoticed within Korea. It is imperative to identify the characteristics of effective professional development programs in order to develop a more functional program. This study identifies fundamental issues and obstacles that are faced by professional development programs for science teachers. Based on this analysis, a framework is proposed that will enable teachers to continue learning throughout all stages of a teaching career.

METHODS

Related literature was reviewed and policy documents were analyzed. In-depth interviews were conducted with 31 intentionally selected science teachers nationwide. An additional data source was a focused discussion between the 16 coordinators of professional development programs at the provincial offices of education and 12 professors of science teacher education.

RESULTS

The study's results indicate that professional development programs for science teachers are not providing relevant content. Additionally, these programs are primarily lecture based, and don't provide opportunities for teachers to reflect on their teaching practices, which makes them passive learners. Summative assessment at the end of each program was given as a written and multiple choice test, where test scores were utilized for teacher promotion. Consequently, real learning and implementation of program content was not effectively measured. Coordinators expressed difficulty in developing professional development programs for the current reform agenda, in developing programs appropriate for different stages of teachers, in locating lecturers that follow program curriculum, and in recruiting teachers to participate. The focused discussion group revealed that there was no system of professional development that addressed the changing needs of science teachers throughout their careers.

CONCLUSIONS

To successfully facilitate creativity through student-centered teaching strategies, math and science teachers must maintain a current knowledge base of scientific and technological progress as well as innovative teaching strategies. Professional development programs must provide relevant content to existing school curriculum in consistency with reform policies and newly developed curriculum. Above all, professional development programs must be designed, assessed, and implemented on the basis of individual teachers' needs at different stages. An effective framework of professional development programs for science teachers will incorporate a long term plan for continuous growth throughout a teaching career. This framework for professional development programs will function as a mechanism for the continual deepening of knowledge and skills necessary for teachers to maintain high educational standards.

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A RELATIONSHIP BETWEEN THE UNDERSTANDING OF CREATIVITY AND THE METAPHORS USED IN DESCRIBING TEACHING STYLES

Hae-Ae SEO
Pusan National University
haseo@pusan.ac.kr

Myeong-Kyung SHIN
Gyeongin National University of Education
mkshin@ginue.ac.kr

Jeong-Woo SON
Gyeongsang National University
cnbe@gnu.ac.kr

Bong-Woo LEE
Dankook University
peak@dankook.ac.kr

ABSTRACT

Facilitating creativity is a major goal in gifted education, and teachers must have a more comprehensive understanding of creativity in order to implement effective teaching strategies. In 2005, 158 teachers of gifted classes completed an open ended questionnaire asking them to describe their perceptions of creativity and to express their teaching style through the use of metaphors. This study indicated that teachers who have a more balanced understanding of creativity tended to use metaphors such as painters, inventors, architects, and designers. However, teachers with an incomplete understanding of creativity more often described themselves as coaches, commanders, leaders, etc.

Keywords: *science and math teachers in gifted education, metaphor about teaching, creativity.*

INTRODUCTION

In order to encourage the development of gifted students, gifted education emphasizes differentiated curriculum and individualized teaching and learning according to each student's ability and potential (Kaplan, 1991; Van-Tassel Baska, 2003). Therefore, the success of gifted education may depend on the extent to which learner-centered teaching and learning is provided (Hansen & Feldhusen, 1994). The most effective teachers for the gifted can be better selected by evaluating their abilities and skills in implementing learner-centered teaching.

Studies focusing on the characteristics of teachers for the gifted have revealed that more successful teachers tend to employ teaching strategies based on proven theories of gifted education as compared to less successful teachers (Hanninen, 1988; Tomlinson et al., 1994). Furthermore, it has been found that successful teachers posses competencies in teaching critical thinking skills, problem solving skills, and creativity (Chan, 2001; Starko & Schack, 1989; Story, 1985). Due to the fact that facilitating creativity is one of the primary goals in gifted education, teachers must be competent in the use of differentiated teaching strategies for developing creativity.

Although various components of creativity were recognized and introduced by many researchers, Urban's components were the most widely accepted in Korea's gifted education program. Urban (1995) suggested three main components in the development of creativity, which related to cognitive, personality, and environmental factors. Cognitive aspects of creativity included divergent thinking, general knowledge, and domain specific knowledge and skills. Personality related factors included task commitment, motivation, openness, and tolerance of ambiguity. Individual, local, and global environmental components were also suggested to be important. According to Urban (1995), these three components interact to facilitate creativity. This view is favored in gifted education in Korea because it helps teachers to recognize multiple dimensions of creativity. Consequently, teachers are expected to have an understanding of all three components of creativity.

Previous research revealed that teachers' views of creativity differed from the traditional views (Dawson et al., 1999), and there was an indication that there might be cultural differences as well (Chan & Chan, 1999). Thus, to facilitate creativity in gifted education in Korea, it seemed necessary to study Korean teachers' understanding and perceptions of creativity. Additionally, an assumption can be made that teachers in gifted education who have a more complete understanding of creativity will be better prepared to implement more effective teaching approaches.

In this study, we first examined teachers' understanding of creativity using Urban's cognitive, personal, and environmental components. Second, we evaluated teachers' perceptions about their own teaching style by evaluating their use of metaphors in expression. Finally, we analyzed how each teacher's understanding of creativity related to their choice of metaphor in describing their teaching style.

METHODS

Data were collected using opened-ended questionnaires from a total of 158 teachers including 40 science and 23 math teachers at elementary schools and 67 science and 28 math teachers at the middle school level in August 2005. This questionnaire was administered during participation in an in-service training program for gifted education. Teachers were asked to define creativity and to choose a job as a metaphor for their teaching style. The relationship between teachers' understandings of creativity and their use of metaphors was then analyzed.

RESULTS

It was found that most teachers mentioned the cognitive aspects of creativity, which indicates an incomplete understanding of creativity as a whole. Only a few teachers had a well-balanced view that mentioned the three components. Science teachers' understanding of creativity appeared to be more comprehensive than mathematics teachers, who rarely mentioned any aspect of creativity but the cognitive. Teachers whose understanding of creativity skewed toward the cognitive component often described themselves as a sports coach, ship captain, team leader, etc. Teachers who mentioned the cognitive aspects as well as environmental conditions were more likely to describe their teaching with metaphors of painters, inventors, and designers. These teachers are considered to utilize student-centered approaches more often.

CONCLUSIONS

To successfully facilitate creativity through student-centered teaching strategies, math and science teachers must have a well-balanced view of creativity. Therefore, teacher training programs should incorporate education about multiple dimensions of creativity. Additional studies might further investigate the correlations between individual teacher characteristics and their teaching styles and understanding of creativity.

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PAIWAN YOUNG CHILDREN'S IDEAS ABOUT SHADOWS

Yueh-Suey Shiao

National Taitung University, Taiwan

ysshiao@nttu.edu.tw

Ching-Yi Chang

Tajen University, Taiwan

ccy@mail.tajen.edu.tw,

Shu-Min Chen

National Pingtung University of Education, Taiwan

shumin@mail.npue.edu.tw

ABSTRACT

The main purpose of this research explored the conceptions of shadows of 16 Paiwan children, who are aboriginals in Pingtung County (southern of Taiwan), from ages 4 to 5 selected from four kindergartens. The concept of shadows was explored from different ways such as shape, size, orientation, tint and awareness of shadows, and the relationship between light sources and shadows. The children were interviewed to answers questions about shadows by choosing the right pictured card, and gave reasons after the choosing. The qualitative and quantitative data were collected. Results showed that children with age 5 understood the concept of shadows in some degrees better than those with age 4 except the awareness of the shadow in daytime, the explanation of the direction of shadow, and the influence of light intensity and object transparency.

Keywords: *aboriginal children, shadow, conceptual development*

INTRODUCTION.

Few studies have been done about the conceptions of shadows of children below ages 6. Segal and Cosgrove's (1993) study is the only one who investigated children below ages 6 about their ideas of shadows. They found that most of five-year-olds thought of shadows as a part of the object and light as for shadows to push out or to be seen. How do four- and five-year-olds think about the orientation, tint, size, and shape of shadows? The purpose of the study was to investigate the ideas of Paiwan (aboriginals in southern Taiwan) children below ages 6 about the orientation, tint, size, and shape of shadows.

METHODS.

Seven four-year-olds and nine five-year-olds (3 boys and 6 girls) were selected randomly from 2 private and 2 public kindergartens in Paiwan aboriginal areas in Pingtung for the study. No shadow related curriculum has been implemented in these kindergartens during the interview period. The major task included 10-item questions with answers on two separate color pictured cards, which contained a correct and a wrong situation of shadows. The task was modified from Osborne and Gilbert's (1980) interview techniques. The children were interviewed individually in a semi-structured protocol, which included asking questions and answering them by choosing a correct card and then explained why they chose them.

The interviews were both audio-taped and video-taped. All the audiotapes and videotapes were transcribed. Children's performance on the task was rated by two raters, and the inter-rater agreement in the study was 94. Mann-Whiteney U was used to compare the performance in Paiwan 4 and 5 years old children.

RESULTS.

Most of the correct responses about shadows of Paiwan five-year-olds and four-year-olds were close. For example, five-year-olds made significantly more correct choices than four-year-olds on the item about the tint of shadows in the pictured task (Mann-Whitney $U= 24$, $P< .05$) (Marascuilo & McSweeney, 1977). Their level of the justifications was significantly higher than that of four-year-olds. Five-year-olds correctly chose the shadows of transparent object than four-year-olds. But four-year-olds made more correct choices than five-year-olds on the item of shadow orientation (Mann-Whitney $U= 7.5$, $P> .05$).

CONCLUSIONS

The conceptions of shadows of Paiwan five-year-olds and four-year-olds are quite similar. Five-year-olds cognized significantly better on the shadow tint than four-year-olds, and four-year-olds better only in shadow orientation. The results give us some important data that there was not much difference between Paiwan 4 & 5 years old children about shadows. They knew the shape and size of shadows, but cognized hazily in the tint and orientation. The result was quite different from that of our previous research in 2007 (Chen & Chang, 2007). It can be investigated in the future research.

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THE GROUP ACTIVITY AT PHYSICS CLASSES: A SOCIO-CULTURAL-HISTORICAL APPROACH

Glauco S. F da Silva

USP

glaucosfs@usp.br

Luciani Tavares

USP

luciani@if.usp.br

André Machado Rodrigues

USP

andremr@if.usp.br

Cristiano Mattos

USP

mattos@if.usp.br

ABSTRACT

In the present work, we examine the relationship between teacher’s and students' classroom activities. We investigated the activity of a group of students solving a Physics problem involving the concepts of "work" and "energy." During problem solving process, the observation of the teacher's interventions was essential to understand the changes occurred in the students' activity. The interaction between the teacher and students reorganize and redirect the activity, causing them to negotiate the objectives and available tools within the activity. A critical look at the teacher’s actions gives us insight into the learning process beyond group development in the solution of a Physics problem. To structure this analysis we used Activity Theory, as well as two principles that are seen as a foundation: mediated action and dialectical relation between the development of human psyche and the development of human activity.

Keywords: *Activity Theory, groups, dialogical interaction, problem resolution.*

INTRODUCTION

In this paper we analyze a case study involving a group of students solving a Physics problem under their teacher’s orientation. We investigated the interactive processes that occurred in the group during a specific task. We aim particularly at understanding the teacher's intervention in the group and the consequences of this intervention to the group dynamic. We use some categories of Activity Theory from a socio-cultural-historical perspective. Generally, investigations of groups go through two theoretical and methodological ways of analyzing products and processes: the “product analysis” usually highlights the end of the tasks, i.e., the outcomes produced by the group; on the other hand, the “process analysis” addresses the dynamic development of the group. In this work we looked at processes believing that this microgenesis study can give complex information about the relationship among students and the completion of the specific task: the resolution of a Physics problem. For instance, Hake (1998) suggests that interactive engagement lead to better results than single lectures when one works with students organized in groups. We also point out to Heller’s work (1999) and the creation of a structure of Physics problems to be solved specifically by groups of students.

On the other hand, we believe working in groups does not guarantee the success of a task solution in itself. A lot of other elements should be considered when studying group dynamics. For instance, the teacher's intervention in group activities reorganizes the task, changing the dynamic of the group interaction and learning.

FRAMEWORK

Activity Theory emerged from Vigotski's works and was subsequently developed by Leontiev (1978). This theoretical framework is based on two principles: the first one is mediated action, in which the relationships between humans and the world are necessarily mediated by a tool. Another one is the close relationship between the development of activities and the development of the human psyche, which makes the activity a privileged element for understanding the psyche.

Attempting to better understand human activity, Engeström (1987) points out to implicit elements in Leontiev's version of the activity theory stresses the idea that activities should be considered as units of analysis, considering that they consist of the smallest and simplest unit that still preserves the essential unity and integral quality behind any human activity (ibid, p. 100). The author inserted three other implicit elements in the basis of human activity: community, social division of labor, and rules.

From this point of view, human activity is organized on triadic relationships: subject–object mediated by tools; subject–community mediated by rules; community–object mediated by social division of labor. Engeström highlighted the organization of activities, allowing us to understand the production, distribution, and exchange (or communication) within human activities. In our specific case study, Engestrom's contribution enables us to understand the interaction among activities, i.e., students' activities and teacher's activities.

METHODOLOGY

Data were collected from a first-year class of high school students at a Brazilian private school. Students ages ranged from 14 to 16 years old. We used the technique of participant observation, where the researcher remains in the research environment during classes, sometimes collaborating with the teacher and making field notes. Video records were also used to provide further details of the group dynamics.

CASE STUDY

We analyzed one group among 7 others. The task students had to solve was an exercise where they needed to use the Physics concepts of work and energy. The problem consisted of an elevator carrying some people from the fifth to the ninth floor. The goal was to calculate the work of the weight and energy spent in the process. To do that students had to estimate the resultant and calculate the total weight loaded by the elevator.

The teacher asked each student to perform different functions to solve the task, allowing the participation of all members during the fulfillment of the task. Students played the roles of *leader*, responsible for carrying out the task; *recorder/checker*, in charge of writing the resolution of the exercise; and *skeptic*, responsible to ensure that other members understand the solution (Heller, 1999).

Our focus was on the teacher's interventions during the task. The main reason to look at this situation lies on the fact that the teacher reorganized the actions of the groups each time he interfered, stimulating the activity.

We observed that every intervention by the teacher promoted significant changes in the group activity. These changes occurred in different spheres of mediation during the activity. The first intervention was the initial distribution of the students' roles in the group (*leader*, *recorder/checker*, and *skeptic*), determining modes of interaction among students through a social division of labor. During the class, the teacher intervened indirectly by redistributing roles, thus reorganizing the social division of labor. The rearrangement of the interaction rules among students reflected directly upon and changed the way the groups solved the problem.

All the times the teacher provided new mediation tools—such as new concepts—the activity was reordered by the change in its goals. There were two modes of interaction allowing for this change, when the teacher re-signified some meanings of the context of the questions, which demanded the renegotiation of the goals previously understood by the students. They changed their focus and traded some subjects by others during their task. The second mode occurred when the teacher taught, i.e., when he provided a specific content explanation (by giving a definition, for instance) that explained the concept of work. In each case the teacher provided new tools, enabling students to move on in terms of solving the problem.

DISCUSSION AND CONCLUSIONS

Looking at the teacher's interventions in the groups of students, we could see that the teaching activity is coordinated with the activity of students. Understanding that teachers and students are engaged in a "school activity" for different reasons allows us to realize that the teacher's interventions are not always productive in terms of problem solving tasks. In fact, the teacher is not directly interested in the solution of the problem, but on the acquisition of certain concepts. It is this wider context that allows us to understand the teacher's interventions as an inquiring action instead of a simply informational action where he gives specific content explanations.

Finally, group development processes help us to understand the learning experience in a broader sense. Beyond the product of the solving problem activity—problem solution—students are dealing with a higher layer of the learning process—*learning as an activity of transformation*—which means they are learning how to negotiate meanings, to scheme and scan their textbooks, asking for help from their most capable peers for answers, and developing other problem solving skills. The dialogical interaction is an important skill to be developed by Science teachers as one of the main ways to teach scientific collaboration and inquiring.

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INNOVATIVE PRACTICES IN SCIENCE EDUCATION - ARE THEY TRANSFERRABLE?

Špela Stres

Jožef Stefan Institute

spela.stres@ijs.si

ABSTRACT

We have chosen 5 different innovative practices of connecting science to educational system, including the one of Jožef Stefan Institute, which will be presented in the format chosen to give information and features we think are important to communicate to another country.

This abstract will be used in the symposium program to describe your presentation. The abstract should be fully justified.

Keywords: *science education, transferability, EU, innovative*

INTRODUCTION

What information should we collect in order to describe the innovative practices well enough to be understood and chosen by another country in order to make science education more comparable through different countries? How do we distinguish a good innovative practice from an average one? What information do we have to receive in order to be able to choose a practice and adopt it in our own country?

We have chosen 5 different innovative practices of connecting science to educational system, including the one of Jožef Stefan Institute, which will be presented in the format chosen to give information and features we think are important to communicate to another country, as e.g. Subject/ Time needed/ Methodology/ Age level; What percentage of teachers at the school/subject level participate in the innovative practice?; How relevant is the support from the school headmaster and management in general?; What is the connection to the curricula (from the stage where it is already included - no major changes necessary up to proposals that are completely out of the curriculum - time and content-vise); Are the teachers already qualified to participate in this innovative practice? Do they need extra tutoring or education to participate in the innovative educational practice?; Where are the reasons that the activity under a particular innovative practice is not higher?

THE CURRENT STATUS OF SCIENCE EDUCATION IN EUROPE

Acknowledging that a meaningful comparative study between different innovative practices (IPs) can only be made on a basis of numerical indicators, such indicators will be presented together with the five cases, as an example of how the indicators can be used. Some of the indicators we suggest will be presented to answer questions like - What are the the main difficulties in science education and how to overcome them.

In a broader sense this work is connected to the FP7 project kidsINNscience, where 8 European and 2 Latin American partners are thinking about how to the form a general information on what is important for contextualizing the innovations, the state of science education and of science education innovation in our countries - in particular to enable innovative practices to be transferred among countries. The project itself has just started in November 2009, so results of this presentation are preliminary and are in this contribution focused on one country - Slovenia.

METHODS: national context based proposal on indicators

To establish a possibility of comparison in innovative practices of different countries, a necessity of measurable indicators has been observed. The indicators were proposed in the first phase for the evaluation of the learning environment as one of the most important parts of the learning process.

RESULTS: THE INNOVATIVE PRACTICE CASE TO BE EVALUATED FOR TRANSFERRAL

Often children in kindergarten are left out of the science education system.

This elimination leads from the starting point inevitably to the low interest in science and technology that we observe in general today.

The described innovation is part of the compulsory curriculum, since all children of this age need to be faced with certain scientific concepts. The expansion of this practice is its inter-disciplinary and the fact that it does not deal with disconnected problems, but rather with a story, connecting all the issues in question.

It represents one of the "best practice examples" in Slovenia. Even though the Curricula enables and supports such approach, there is a small number of of such advanced approaches in Slovenia.

Main focus of the innovative practice: science contexts, scientific competencies, knowledge of science and/or knowledge about science, attitudes toward science, following PISA 2006 categories /reference/ . The approaches used in the kindergarten - the context:

5. setting and testing the hypothesis, - scientific competencies, knowledge of science and/or knowledge about science
6. learning process based on sources finding - scientific competencies, knowledge of science and/or knowledge about science
7. "hands on" experimental approach - scientific competencies, knowledge of science and/or knowledge about science, attitudes toward science,
8. simulation of different "real life" situations - scientific competencies, knowledge of science and/or knowledge about science, attitudes toward science,
9. creative approach - scientific competencies, attitudes toward science

CONCLUSIONS: NEW INDICATORS PROPOSED WITHIN CONSCIENCE PROJECT

however, the usage of the originally proposed indicators established to be impossible with the purpose of evaluation of a particular innovative practice case. Thanks to the Brazilian team of Rio de Janeiro, a new indicator system has been introduced, as can be seen below in **Figure 1.**

Evaluation of general status of the status in the particular age group and subject group was carried out to find out that the result is only 54 out of 100 points. This is not a surprising result, since the general field status is not comparable in quality and potential to the presented innovation case already on a subjective level.

However, we were looking for ways to prove this and with the indicators the possibility arose.

ACKNOWLEDGEMENTS

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CONCEPTS OF DENSITY AND BUOYANCY IN EIGHTH GRADE OF PRIMARY SCHOOL

Katarina Susman

University of Ljubljana, Faculty of Education

katarina.susman@pef.uni-lj.si

Jerneja Pavlin

University of Ljubljana, Faculty of Education

jerneja.pavlin@pef.uni-lj.si

Saša Ziherl

University of Ljubljana, Faculty of Education

sasa.ziherl@pef.uni-lj.si

Mojca Čepič

University of Ljubljana, Faculty of Education

mojca.cepic@pef.uni-lj.si

ABSTRACT

The teachers' practice shows that the conceptual understanding of buoyancy among primary school pupils is often deficient. Therefore we have made a design experiment, which includes a unit about floating and sinking. The aims of the unit are: evoke intuitive notions and use it as a starting point on which we build (develop) physical concepts and gradually expand students' understanding of density and buoyancy. The unit was tested among eight grade pupils in two primary schools. In the contribution the results and responses on active learning approach will be presented.

Keywords: *density, buoyancy, conceptual understanding, survey*

INTRODUCTION

An everyday life offers pupils many situations connected to terms of density and buoyancy. Objects float or sink in the liquids and the intuitive notions of pupils in the eighth grade (age 14) are mostly developed in a way that they are able to predict which of the objects will sink or float. The connection of intuitive notions with the theory and conceptual knowledge is often the most demanding part of learning.

Many surveys confirm that the concept of buoyancy is difficult to understand and deserves a precise explanation and well prepared classes (Loverude et al., 2003; Heron et al., 2003; She, 2005).

A proper teaching strategy is therefore needed. In this contribution we present the teaching unit that includes constructivistic aspects and combines pupils' intuitive notions with theoretical concepts.

METHODS

The teaching unit has four steps arranged in a way that each step coincides with one school hour of 45 minutes. It is based on discussions and active learning. Both teaching strategies in corroboration of statement writing in the notebooks stimulate the scientifically correct way of expression and help pupils to overcome intuitive notions and lead them to understanding of concept (Čepič, 2006; Razpet, 2006).

The teaching strategy that is proposed was realized as a preliminary study in year 2008 (29 pupils of age 13). The design researches lead us to improve some weak parts.

Teaching in the class was repeated in December 2009 in two classes (46 pupils of age 13). A parallel study was performed in classes where standard teaching process was taking place. A comparison of pre-knowledge in both groups of pupils will be presented as well as the results of the post test. The research questions were connected to pupils' improvement in knowledge and conceptual understanding of density and buoyancy as well as on the comparison between the test and control group. The research is also aimed to test the efficiency and adequacy of teaching unit for teaching the difficult concepts. Both groups of pupils had the same pre and the post test.

The pre and post test included a few general questions about the age, sex and interests of pupils. The pre test and post tests have questions connected strictly with one of the concepts (density, buoyancy) and questions that combine both.

After the lessons a few pupils were interviewed and recorded. Data collection included pre and post tests of all pupils, interviews of 3 pupils from each class and by classroom observations (field notes). Three observers were helping at experiments and detected the comments and discussions in the class. During the lessons the notes about the atmosphere and pupils activities were performed. Analysis of the data was mostly qualitative (analysis of interviews, field notes from observers during the classes). Quantitative part was focused on some questions from pre and post test, while the other questions were open, which deserved qualitative analysis.

RESULTS

The results indicate that the hypothesis about active learning and assimilated concepts was correct. Pupils describe the teaching unit as attractive and motivative. The memory about the experiments and their explanations did not reduce significantly in three month period. It was surprising that some details were still reproduced in precise way. The research proved problems in the jump from common to scientific language. The Slovene language in a daily talk uses some misleading expressions from the physics points of view. The intuitive notions and expressions from a daily life are coinciding. Through the process of learning the descriptions of the concepts should improve from common language to scientific language.

CONCLUSIONS

Based on the findings of this study it can be concluded, that the concept development of the phenomenon buoyancy can take place by means of a proposed unit. The students develop the meaning of the concept using their intuitive notions and discussion.

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3R, THAT IS REDUCE, REUSE, RECYCLE

E. Odrowąż

Faculty of Chemistry
Jagiellonian University
ul. Ingardena 3
30–060 Krakow, Poland

odrowaz@chemia.uj.edu.pl

M. Krzeczkowska

Faculty of Chemistry
Jagiellonian University
ul. Ingardena 3
30–060 Krakow, Poland

krzeczko@chemia.uj.edu.pl

E. Szostak

Faculty of Chemistry
Jagiellonian University
ul. Ingardena 3
30–060 Krakow, Poland

szostak@chemia.uj.edu.pl

ABSTRACT

As a result of the education system restructuring in 1999, new subject – science – has appeared in primary schools. Students of the faculty of Chemistry of the Jagiellonian University, have the opportunity to gain qualification to teach this subject. Students are obliged to participant in different forms of didactic activities – lectures and seminars. It seemed advisable that after a few years experiences check which forms of didactic activities seems to be the most useful for students as future teachers. Particular emphasis was placed on classes related to introduction of the environmental protection issue in the school. The preliminary results of our research will be presented on poster.

Keywords: *science education, environmental education, didactic materials.*

INTRODUCTION

The Jagiellonian University Faculty of Chemistry students may choose to participate in the “Methodology of Teaching Science” course [1, 2]. The course participants are required to complete courses in which special emphasis is situated on topics that are not covered by the program of study, like biology and geography. The course consists of three parts: “Basic of biology” (lecture - 30 h), “Basic of geography” (lecture – 30 h) and “Science didactic” (seminar – 45 h). The main aim of our research was seminar – “Science didactic”. During the seminars, students are obliged, among others, to observe Science lessons at a primary school, to prepare a school trip plan, a Science lesson plan, and a mini-session plan connected with the problems of environmental protection as well as a final Science test for primary school graduates. In order to facilitate future science teachers familiarize themselves with the general aims of science teaching, which are composed of, inter alia, the practical use of science knowledge, curiosity and respect the world of nature. During the excercise students working in groups prepare and then carry out in a form of workshop "Mini- Scientific Session". The topics of this mini-session vary on each academic year, but there are always topics connected with environmental protection [3,4].

This year, three groups of students prepare project on topic 3 R, that is: Reduce, Reuse, Recycle. The task of each group is to discuss the issue in an attractive way and to encourage students to realize in daily life the slogan [5]: Reduce, Reuse, Recycle

METHODS

In order to better know opinions of any group of individuals a survey was applied (data collection type) as one of the research process steps. Survey is one of sociological techniques for collection of data obtained directly by posing questions to selected people who fill in special questionnaires.

The usefulness of conducting “Science didactic” classes was checked with the use of the questionnaire, which contain 7 open questions requiring in-depth reflection on the subject, and sometimes impulsive answer based on first association and 2 semi-open questions where one suggested answer could be selected and justified. This questionnaire was carried out among students. The purposefulness of conducting classes with environmental education was checked by the second questionnaire. Among the respondents there were:

- primary school pupils, to whom these classes are addressed,
- grammar school students, who have recently finished the primary school,
- high school students, who should be familiar with these issues,
- students who will teach these issues in the future

RESULTS

The preliminary results of the first questionnaire were presented in following tables:

Table.1. Assessment of he usefulness of various forms of work

Forms of work	Students' answers
1. Preparing of the scenerio of the lesson	94,5% absolutely yes or yes
2. Presentation of the scenerio of the lesson	77,7% absolutely yes or yes
3. Preparing of didactic materials	83,3% absolutely yes or yes
4. Preparing of a school travel plan	77,7% absolutely yes or yes
5. Presentation of a school travel plan	61,1% absolutely yes or yes
6. Science laboratory	83,3% absolutely yes or yes
7. Meeting in museum	only 38,8% absolutely yes or yes but 33,3% don't know and 27,8% absolutely no or no
8. Observing of school lessons	83,3% absolutely yes or yes
9. Mini- Scientific Session	55,5% absolutely yes or yes

Table.2. Influence of the participation in the Mini Sesion on the develop of certain skills

Skills	Students' answers
1. the group work competences development	77,7% yes or rather yes
2. the discussion competences development	77,7% yes or rather yes
3. ecological knowledge advances	94,4% yes or rather yes
4. active methods knowing	only 55,5% yes or rather yes

The questions of the second questionnaire were grouped into four categories, testing:

1) understanding of ecological terms and the attempt of their application in daily life
2) suitable pro-ecological application
3) acquaintance of action principle
4) students' opinions about pro-ecological actions

Results indicate that pupils are familiar with environmental issues but not always they knew how to used this information in everyday life.

CONCLUSIONS

The results obtained confirm the desirability of conducting didactic activities to enable students to acquire skills to teach about environmental issues. At the same time shown that forms of didactic activities during the course of "Science Didactic" were chosen properly

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FRAMING DIGITAL COMPETENCE FOR SCIENCE TEACHING

Andrej Šorgo

University of Maribor, Faculty of Natural Sciences and Mathematics, Maribor, Slovenia

andrej.sorgo@uni-mb.si

Andreja Špernjak

University of Maribor, Faculty of Natural Sciences and Mathematics, Maribor, Slovenia

andreja.spernjak@uni-mb.si

ABSTRACT

The basic question in modern times is how to educate students to perform appropriately in situations that were unknown during their educational period. The European Parliament has published a framework of key competences for lifelong learning. For science teachers, this means that they need not only to possess these competences but also to prepare teaching activities in such a way to enhance development of these competences in their students. In the case of digital competence, this mean that science teachers must be able to use a much broader array of applications and handle equipment which is not used by teachers of other subjects.

Keywords: *Computers, Digital competence, ICT, Science teachers, Teacher education*

INTRODUCTION

If we recognize the demand for flexible and better educated digitally competent citizens as one of the main goals of educational systems (Bawden 2001; Illeris, 2008, p. 2), then teachers have to be one step beyond their students. Teachers should not only possess the appropriate knowledge, skills and attitudes towards the proposed competences but must also be additionally competent in pedagogy for their successful classroom implementation in order to enhance learning. As a suitable theoretical framework towards the development of teachers' competences, we can use the model of Technological Pedagogical Content Knowledge (Mishra and Koehler, 2006).

METHODS

Article is based on authors' first-hand experiences in introduction of computers in biology teaching at secondary general and higher vocational schools and trainings of in-service and pre-service biology teachers.

DIGITAL COMPETENCE IN SCIENCE TEACHING

One of the basic competences is digital competence, which *"involves the confident and critical use of information society technology (IST) and thus basic skills in information and communication technology (ICT)"*. In the case of teachers, we can recognize the double role of ICT in their lives. The first role is to fulfil their personal needs as digital citizens with their skills in and knowledge of computers in their role of clerical, informational and multimedia tools. On the professional level, their role does not end with the use of ICT to improve their teaching content, to support school administration and to function as a desk-top library; in addition they have to cooperate with other educators in an effort to educate digitally competent students.

As science educators, we can easily recognize that general definitions and frameworks concerning digital competence (digital literacy, ICT-competence, etc.) in school work are too narrow because science teaching, especially in practical, laboratory and field work, goes beyond common teaching practices used in most other subjects. On the other hand, demand for the use of digital technology in school laboratories, field-work, or the classroom creates additional responsibility for science teachers. Students can use computers as sophisticated typewriters, as desktop libraries, or communication tools, and for multimedia in literally every subject, while the use of ICT units as processors, controllers, and data-loggers can be introduced in only a limited set of school subjects or activities. In this case, if, for example, one teacher at a school does not promote the use of computers in the classroom as a tool for finding information, the loss for students is minor, because with equivalent work in other subjects they can fill the gap. If, on the other hand, science teachers do not use data-loggers in the school laboratory, there is nobody at school to cover the missing knowledge.

LEVELS OF DIGITAL COMPETENCE IN SCIENCE

As a framework for setting competence levels for digital competence in Science we have used and modified levels from Bloom's revised Taxonomy (Krathwohl, 2002). First, we can recognize three levels of digital competence. At the first level are competences defined in the Framework as digital key competence, which should be common to all citizens. At the second level are general professional competences that are common to all teachers, but not to other professions. At the third level are the special-professional digital competences of Science teachers. Such a competence is, for example, the use of data-loggers in the school laboratory. The second divide lies at the level of mastery of digital applications and competence to soundly use them in a classroom. We cannot recognize expertise simply by counting the applications that are used by a teacher. We believe that reaching an expert level in digital competence in Science teaching is a difficult task because of the need for mastery of a wider list of digital equipment and software than in most other subjects.

TEACHER EDUCATION FOR DIGITAL COMPETENCE

Science teachers' education for the integration and full exploitation of available digital technology cannot stop at the level of courses where they are taught only how to use equipment or software, but must include pedagogy and the provision of context where and when such technology can be used. According to Guzman and Nussbaum (2009), teacher education should consist of several domains: instrumental / technological, pedagogical / curricular, didactic / methodological, evaluative / investigative, communicational / relational, and personal / attitudinal. One problematic challenge for many universities that offer teacher education is that existing courses concerning ICT and multimedia are headed by ICT experts, who are rarely experts in, for example, Biology and Didactics. As a result, connections between domains must be made by students, a task which can be demanding at least at the pre-service level. On the other hand, experienced teachers have already built their personal pedagogical content knowledge which, if successful, cannot be easily changed.

CONCLUSIONS

We can conclude that we cannot frame digital competence for science teaching in line with similar training for other teachers. Science teachers can at least potentially use applications and equipment not used by teachers of other subjects, which gives them a heavier responsibility in achieving such competence. Simply sending them to a course or including such a course in pre-service training will fail if they do not find support when they are back in school or when they start teaching.

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ACCOMODATING THE MODEL OF PARTNERS IN LEARNING TO INCREASE ACADEMIC ACHIEVEMENT & NURTURING SOCIO-CULTURAL AND HUMAN VALUES OF ELECTRONIC UNDERGRADUATE STUDENTS

Fatemeh Talebzadeh

YOUNG RESEARCHERS CLUB, ISLAMSHAHR BRANCH OF ISLAMIC AZAD UNIVERSITY
TEHRAN-IRAN

Bahar1979@yahoo.com

Mohammadreza Behrangi

IOSTE REGIONAL OFFICE FOR COUNTRIES AROUND PERSIAN GULF SCHOOL OF PSYCHOLOGY AND EDUCATION, DEPARTMENT OF EDUCATIONAL ADMINISTRATION, TARBIAT MOALLEM UNIVERSITY
TEHRAN-IRAN

Behrangimr@yahoo.com

Mahmoud Samkan

ELECTRICAL ENGINEERING FACULTY,
AIR UNIVERSITY
TEHRAN-IRAN

Msamkan@yahoo.com

ABSTRACT

The purpose of this article is to compare the effects of two different teaching methods on students' academic achievement, attitudes, and socio-cultural and humane values. We chose: "Partners in Learning" and "traditional" teaching methods. Semi-experimental research approach was used for a class composed of 18 undergraduate students and the result was compared with the control group with the same size. The result of T-test indicates the meaningful increase of main scores of students in the experimental class of Industrial Electronic laboratory. Therefore, this model could be used for developing socio-cultural and human values and enhancing students' creativity.

Keywords: *Models of teaching; partners in learning; group investigation; effective education; human values; cultural values.*

INTRODUCTION

The concepts of teaching science have been confronted with drastic changes in the contemporary world of education. According to Hyte's "Art of teaching", writing an article about the art of teaching is a difficult job, because the subject is continuously changing. The model of "Partners in Learning" needs professional and skillful teachers who will be able to apply it in the classrooms successfully. Johnson (1974, 1981, 1990) and Sharan (1990) and many others are the supporters of this method which is in contrast with individual competitive method. In this method the learners learn in small groups with mutual cooperation.
Effective training requires a particular method; it is not practicable through restricted, old teaching methodologies. Our main concern is to determine tasks and activities which can be used to improve educational quality as well as planning considering socio-cultural and human values.

METHODOS

In this research we are trying to show the differences between "Partners in learning" and "traditional" teaching methods. Two classes each containing 18 students were chosen on the same course using Semi-experimental approach and the Independent T-Test for both experimental and control groups. For eight weeks one class was trained based on the "traditional method" and the other on "partners in learning", on the same subjects. At the end of the course a questionnaire made by the researcher was distributed among the students. The questionnaire includes 40 items with 5 rate Likert scale which determines its validity and reliability. The items were categorized into 4 components of individual, behavioral, social and cognitive effects on students' socio-cultural and human values. Scores and grades of the classes were compared and measured and are shown in Tables 1 and 2. These tables imply that the model of "Partners in Learning" will increase and develop students learning more than the "traditional" method. The T-Test and SPSS software have been used to analyze statistical data.

RESULTS

In this research, inferential statistics has been applied to analyze the data. It should be noted that it's a two-tail test since the directions are not distinct, that is (H_0= μ1=μ2) and two samples are equal (n=n). As a result the assumption of the equivalence of variances is generally proved. The independent T-Test has been used to analyze data that is presented in detail in the following tables.

Table 1. Independent T-Test between survey questionnaires of students

Indexes / Groups	Average difference	Standard deviation from average	T measure	(df) degree of freedom	Sig. level
Traditional & partners in learning method	59/05	9/19	6/42	34	0/000

The t score is estimated as (t=6/42) with the degree of freedom of df: 34, which was chosen from the Table at the probability level of 0/05 with the crisis level of (t=2/05), as a result the null hypothesis is rejected and the research hypothesis conveying that students' learning and development are increased by the "Partners in Learning" method is supported.

Table 2. The independent T-Test between students' mean scores

Indexes / Groups	Mean Difference	Standard deviation	Standard deviation from average	T Measure	df	Sig. level
The partners in learning & Traditional method	2/61	2/77	2/61	3/16	26/13	0/004

Regarding the absolute value of calculated t (t=3/16) and the degree of freedom (df: 26/13) at the probability level of 0/05, that is more than the t on the table (at crisis level t: 2/056), the null hypothesis is rejected and the research hypothesis is supported that students' learning and development are increased by the "Partners in Learning" method.

CONCLUSION

Because the quality of all the professions and jobs result from educational system, therefore selecting proper method for teaching and learning has a vital importance. Implementing the model of "Partners in Learning" could have a significant impact on socio-cultural and humane values as well as students' academic achievement. The students are not only actively participating in learning, but they can also experience their success in learning. Recognizing its significant success in learning it is recommended that further researches in other selected teaching methods be done in order to be able to generalize the findings.

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INDIAN SECONDARY STUDENTS' VIEWS ABOUT GLOBAL WARMING: BELIEFS ABOUT ACTIONS AND WILLINGNESS TO ACT

Neil Taylor
University of New England
ntaylor6@une.edu.au

Edward Boyes
University of Liverpool
qe04@liverpool.ac.uk

Martin Stanisstreet
University of Liverpool
martstan@liverpool.ac.uk

Kiran Chhoker
CEE, Delhi
kiranc@ceeindia.org

Shweta Dua
CEE, Dehli
shwetadua21@gmail.com

ABSTRACT

A 44-item survey instrument was designed to determine secondary students' views about how useful various specific actions might be related to reducing global warming, their willingness to undertake the various actions, and the extent to which these two might be linked. The instrument was administered to students in years 7 to 10 (n= 768) from four large English medium schools in Delhi, India. The findings indicated that this cohort of Indian students exhibited very high levels of concern about climate change and strong willingness to act against global warming. The findings are compared with those from two similar survey studies conducted in Western contexts.

Keywords: *Global warming; India; attitude, behaviour, environmental education.*

INTRODUCTION

There is considerable evidence that simply imparting environmental knowledge does not in itself necessarily influence attitudes and behaviours and as such is insufficient to bring about positive environmental impacts (see e.g. Jensen, 2002), as environmental knowledge and pro-environmental behaviour are not particularly strongly linked (Hungerford & Volk, 1990). Rajecki (1982) has argued that there is what has been termed as a 'gap' between knowledge and action. Clearly, as efforts to reduce the contributing factors to global warming must inevitably involve individuals in taking positive environmental actions, it is important to explore the nature of this 'gap' and ways in which it might be bridged or circumvented. However, it has become clear as workers have attempted to generate models of the drivers of environmentally sympathetic behaviour that there are limitations in studying links between environmental attitudes in general and potential behaviour patterns (e.g. Stern, 1992).

To circumvent this issue Boyes, Skamp and Stanisstreet (2009) developed a survey instrument that questions respondents about their specific environmental behaviours and the possible effects of these particular actions on the amelioration one environmental problem - global warming. To date this instrument has been administered to secondary students in Australia and Spain. The study reported in this paper was undertaken using the same survey instrument with 12-16 year old students in Delhi, India, and the study addresses three research questions:

1. To what degree do students intend to undertake a variety of specific ‘environmentally friendly’ actions have been studied?
2. To what extent do students believe these particular actions would be effective in reducing global warming have been investigated?
3. What is the relationship between students’ willingness to undertake specific actions and their beliefs about the usefulness of the same actions has been explored?

METHODS

The survey was administered to 768 secondary students (aged 12-16) from four large English medium schools in metropolitan Delhi. The sample comprised 448 males and 320 females across 5 grades. The schools drew largely from middle and upper middle class families. Following their completion, the surveys were numbered, and the responses were scored and entered onto an Excel data file for analysis. Differences between the distributions of responses between students in different year groups, and between male and female students, were explored using Chi squared analysis.

CONCLUSIONS

In general Indian students exhibited a much greater willingness to take action against global warming than students of a similar age in Australia or Spain. There is always a risk in commenting too definitively on individuals’ intentions or willingness to act, as these intentions may never translate into actual behaviour. Having said this it was interesting to note that in general India students indicated quite a strong willingness to act against global warming and consequently in favour of the environment. There may be a number of reasons for this. At all of the India secondary schools where the survey was administered, environmental education (particularly non-formal EE) was clearly afforded a high profile with support for Eco-clubs, environmental displays and environmentally orientated assemblies. The survey was administered around the time of Earth Day, and this event was being taken very seriously in all of the schools, with teachers and students clearly engaged in raising environmental issues often related to global warming at school assemblies. Furthermore, most commentary about environmental issues in developing countries such as India is linked to social justice with authors such as Kothari and Parajuli (1993) viewing the achievement of social justice as a prerequisite to ecological sustainability. The argument being that the poor of the world are simply struggling to survive and as such do not have the option of the ‘privilege of concern’, something these authors argue is the preserve of the wealthy ‘middle class’. The latter group they argue have the financial ability to look beyond their own livelihood and explore global issues. However, in this particular study the issue of social justice preceding favourable environmental action may not have been applicable given the nature of the sample that drew largely from middle class Delhi. As such this group unlike the majority of Indians probably did have the ‘luxury or privilege’ of concern and could therefore explore global issues, thus perhaps explaining there apparent willingness to act against global warming. However, as some of these students may go on to be future leaders in private enterprise and the public sector, it is an encouraging sign that they do appear to be willing to take action for the environment.

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PRIMARY SCHOOL CHILDREN'S DIRECT EXPERIENCE OF AND ATTITUDE TOWARD TOADS

Iztok Tomažič

University of Ljubljana, Biotechnical Faculty, Department of Biology,
Večna pot 111, 1000 Ljubljana;

E: iztok.tomazic@bf.uni-lj.si

ABSTRACT

One of the main goals of Slovenian biology and science curricula is that teachers should encourage children to develop positive attitudes toward organisms and nature mainly by enabling them to directly experience organisms and their environments. Children seldom come across toads and their image of the animals is not very positive. The following study presents the development of a Toad Attitude Questionnaire (TAQ), and its results gathered from a sample of 195 primary school children (grades 6–9). Factor analysis produced three meaningful factors which were separately analysed according to students' gender, grade and direct experience of toads. Results show that, on the naturalistic and moralistic attitude dimension, girls rate higher than boys, while according to direct experience, the moralistic attitude dimension in contrast to naturalistic and negativistic attitude dimensions produces no significant difference. We also found significant differences across grades with regard to ratings on the naturalistic attitude dimension.

Keywords: *attitude, animals, toads, direct experience*

INTRODUCTION

Children's image of toads is not a very positive one. Of all amphibians commonly found in Slovenia, it is mainly toads that seventh graders perceive as organisms that can infect a person and give them warts. They generally dislike them and report a high level of disgust toward them (Tomažič, 2009). There are several potential causes for that. Firstly, toads are mainly nocturnal and children rarely come in contact with them. Secondly, the main sources of information about toads are children's parents and grandparents, and TV documentaries, while children acquire only limited information in school. In the last decade there has been increased research of attitudes toward different animals and animal groups (Barney et al. 2005, Thomson and Mintzes 2002, Lucas&Ross 2005, Prokop & Tunnicliffe, 2008). But relatively few articles have been published about the attitude toward amphibians or amphibian species (Tomažič, 2008), although they belong among the most endangered animal groups (http://amphibiaweb.org/). In a research conducted by Tomažič (2009), only between 16% and 18% of seventh graders had direct experience of toads. Children who had already been in direct contact with animals, reported more favourable attitudes as well as lower levels of fear and disgust toward them. In the following study a psychometrically valid scale has been developed, which the author used to assess the attitude of children of different age toward toads, the difference in ratings according to the gender of respondents, and differences according to prior direct experiences with animals.

METHODS

A Toad Attitude Questionnaire (TAQ) was constructed on a basis of other research which employed Kellert's typology (Kellert 1985, Barney et. al., Mintzes & Tompson 2002). A single animal species was selected because measuring a generalised attitude toward amphibians would not yield concrete or valid results (e.g. thinking about turtles or frogs –the prototypical species – when rating amphibians). In September and October 2009 a total of 195 students from three primary schools attending grades 6–9 (aged 10–14) completed the TAQ that consisted of 35 items. The questionnaire was submitted to Factor analysis (with Varimax rotation). After the initial analysis, we decided to retain 25 items that produced three meaningful factors. Cronbach's alpha for the total scale of 25 items was 0.88. Cronbach's alpha for the first factor was 0.88 (nine items), second factor 0.80 (eight items) and third factor 0.74 (eight items). KMO of 0.876 and Bartlett's test of sphericity (1618.5, df=300, p<0.001) supported the use of factor analysis. Total variance explained by three-factor solution was 47.8%. The first extracted factor accounted for 28.8% of total variance.

RESULTS

Factor 1 can be interpreted as naturalistic (scientific), where students rated their interest in the physical attributes and biological functioning of animals and their interest in direct experience of animals. Factor 2 can be interpreted as negativistic, where children expressed an orientation toward active avoidance of animals as a result of disliking, fear or disgust. Factor 3 encompassed statements of moral and utilitarian attitudes, i.e. concern about the right or wrong treatment of animals and the importance of animals to humans. Statistically significant differences between different grades were found only for factor 1 (Kruskall-Wallis test: χ^2=10.830; df=3; p=0.013). There were no statistically significant differences between students' average ratings for each factor according to different schools (Kruskall-Wallis test: all p-values above 0.05). A total of 37% of all students reported direct experiences with animals. There were no statistically significant differences in direct experience of toads between boys and girls (χ^2=0.777; df=1; p=0.378). Statistically significant differences between student ratings according to previous direct experience of toads were present for factors 1 and 2. Students with no direct experience of animals rated significantly lower on those two factors than students who reported having direct experience of animals (Mann-Whitney U test: both p<0.001). With regard to factors 1 and 3 girls scored significantly higher than boys (Mann-Whitney U test : p=0.007 for first factor; p<0.001 for third factor).

CONCLUSION

Results show that the scale can be used across grades 6–9. Although the results in different grades are comparable, it is obvious that older students are not as eager, or motivated, to study toads as students of lower grades. This interest is diminishing from sixth to ninth grade (from average 3.4; SD=1.00 to 2.8; SD=0.76). Direct experience also strongly affects students' ratings in the first two factors which may influence students' willingness to learn about animals. Students should therefore, in the course of primary education, have the opportunity to directly meet and learn about animals in order to develop appropriate attitudes toward them. Teachers should try to help students to overcome negative feelings toward animals, which can be effectively accomplished mainly through direct experience (Tomažič, 2008).

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HOW DO LEARNERS IN DEVELOPED AND DEVELOPING COUNTRIES RELATE TO ENVIRONMENTAL ISSUES?

Ricardo Trumper

Department of Science Education, Faculty of Science,

University of Haifa, Israel

ABSTRACT

The research questions dealt with students' (a) hopes and visions for the future of the environment, (b) personal engagement in the environmental protection issue, and (c) interest in learning about environmental challenges, regarding their countries' degree of development. In the framework of the ROSE project, attention was focused on students' responses to sections related to environmental issues. The findings showed that students in medium and low developed countries are more:

- concerned and optimistic about environmental problems;
- personally and collectively involved in environmental issues;
- interested in learning environmental topics.

Keywords: *Environmental education, attitudes to environment, interest in environmental issues.*

INTRODUCTION

The issue of students' attitudes toward environmental issues has been evaluated by a number of authors, but few systematic studies on environmental concern and attitudes across countries have been done. According to Inglehart (1990), the shift toward environmentalism in the Western world was linked to a post-materialist shift in cultural values. Thus, it was presumed that high levels of environmental concern existed only among people in developed countries. This assumption has been challenged by the results of an international survey on environmental values conducted by Dunlap et al. (1993) which showed that citizens of many developing nations were highly concerned about the state of the environment.

Nowadays, there is a general consensus that environmental education should pay particular attention to students' attitudes and interests, because their level of knowledge and comprehension seems to increase with their concern. Ballantyne and Packer (1996) found environmental conceptions to be very important in the adoption of attitudes and environment-related behaviors. Many students appear to have misconceptions of certain environmental issues. There is a large body of literature on the relationships between knowledge, and attitudes and behavior toward the environment, but findings continue to be mixed regarding relationships among these variables.

Most of the existing studies regarding environmental attitudes were carried out in developed countries. We think there is a need for studying and comparing students' environmental attitudes and interests in developed and developing countries as indicators for environmental behavior, in order to identify what contributions school science education can make in improving these attitudes.

METHOD

The data were collected through the ROSE survey. ROSE, the Relevance of Science Education, is an international comparative research project that was conducted in 2003 and 2004.

In this presentation attention is focused mainly on students' responses to sections and items related to environmental issues: students' attitudes to environmental challenges and their interest in learning about environmental topics. This study comprised 36,728 students from 34 different countries, most of them 15 years old, representing the population of compulsory last-year students in the different countries.

For all of the analyses we used the Human Development Report (HDR) (UNDP, 2003) published annually by the United Nations Development Program (UNDP). In each HDR the countries are ranked according to the Human Development Index (HDI).

The first two parts of this study refer to the section of the questionnaire headed "Me and the environmental challenges". This consists of 18 statements prompted by the question "To what extent do you agree with the following statements about problems with the environment".

RESULTS

Are students' visions for the future of the environment related to their countries' degree of development?

Two items were intended to tap into respondents' future images of the environment: D2 - Environmental problems make the future of the world look bleak and hopeless, and D7 - We can still find solutions to our environmental problems.

On average the students in all the countries agreed with the statement that the future of the world looks bleak and hopeless due to the environmental problems (item D2). Despite that, item D7 displayed a very hopeful profile meaning that students in all countries agree strongly that we can still find solutions to our environmental problems. Nevertheless, looking at the relationship of students' responses for these two items with the HDI, we see that:

1. For D2, an inverse relationship with a Pearson product moment correlation of .674 ($p < .01$), that is, the higher the level of development in a country, the lower students' agreement that the world looks "bleak and hopeless" due to the environmental problems,
2. For D7, an inverse relationship with a Pearson product moment correlation of .486 ($p < .01$), that is, the higher the level of development in a country, the lower students' agreement that we can still find solutions to our environmental problems.

Is students' personal engagement in the environmental protection issue related to their countries' degree of development?

Some items seem to have in common a lack of concern for the environmental issue indicating that environmental problems are overstated (D3: Environmental problems are exaggerated, and D8: People worry too much about environmental problems).

Students' responses showed that, in most countries they disagreed with statements indicating that environmental problems are overstated, although none of them disagreed strongly. There is an inverse relationship between students' responses and the HDI, with a Pearson product moment correlation of .626 ($p < .01$), that is, the higher the level of development in a country, the less students agree that environmental problems are overstated.

Other items describe another aspect of lack of concern, distancing the individual from environmental problems, and sharing an expression that solving these problems is somebody else's job (D1: Threats to the environment are not my business, D11: It is the responsibility of the rich countries to solve the environmental problems of the world, and D13: Environmental problems should be left to the experts).

Students' responses showed that in all countries they disagreed with statements indicating that someone else had to solve environmental problems. There is a somewhat direct relationship between students' responses and the HDI, with a Pearson product moment correlation of .368 ($p < .05$), that is, the higher the level of development in a country, the more students agree that solving environmental problems is somebody else's job.

By contrast, there are items which describe a tendency to become involved in the issue, suggesting that environmental problems can still be overcome, a belief that every one can make an important difference, and evincing some willingness to act. We differentiate personal involvement (items D5: I am willing to have environmental problems solved even if this means sacrificing many goods, and D6: I can personally influence what happens with the environment) from collective involvement (items D7: We can still find solutions to our environmental problems, D10: People should care more about protection of the environment, and D12: I think each of us can make a significant contribution to environmental protection).

On the one hand, students showed little conviction about statements conveying personal involvement in the environmental issue. On the other hand, students showed a greater conviction about statements conveying collective involvement in the environmental issue. Looking at the relationship of students' responses with the HDI, we see that:

1. The higher the level of development in a country the less students are personally involved [Pearson product correlation moment of .444 ($p < .01$)].
2. The higher the level of development in a country the less students are collectively involved [Pearson product correlation moment of .571 ($p < .01$)].

Is students' interest in learning about environmental challenges related to their countries' degree of development?

In section E students were invited to indicate how much they "want to learn about" a series of subjects given in 108 statements, 12 of them addressing environmental protection.

Most developed countries' students scored low, absolutely and relatively, meaning that they did not regard environmental protection as a matter of particular interest, while students in developing countries seemed willing to learn about environmental issues. We got a strong inverse relationship between students' interest in learning about environmental issues and the HDI, with a Pearson product moment correlation of .866 ($p < .01$): the higher the level of development in a country, the lower the students' interest.

CONCLUSIONS

The most salient feature of the findings of this study is a sharp distinction between high developed countries from one side, and medium and low developed countries from the other side. We found that students in medium and low developed countries are:

- more concerned and optimistic about environmental problems;
- more personally and collectively involved in environmental issues;
- more interested in learning environmental topics.

These differences suggest implications for the environmental science education. We think it is important to develop environmental science education programs that are based on each country's own ecological, cultural, political, educational, and economic context.

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THE INFLUENCE OF TEACHER GENDER ON STUDENTS' ENGAGEMENT AND ACHIEVEMENT IN SCIENCE: A NORWEGIAN EMPIRICAL STUDY

Eyvind Elstad

University of Oslo

eyvind.elstad@ils.uio.no

Are Turmo

University of Oslo

are.turmo@ils.uio.no

ABSTRACT

The purpose of the study was to explore relationships between teachers' gender and a range of variables relating to adolescent students' perceptions of their classroom engagement, quality of teaching and responses to their teacher, and their own achievements in science (Elstad & Turmo, 2009). A cross-sectional survey of 798 Norwegian students showed the potential influence of the gender of the teacher on engagement, motivation, volition, and learning outcomes, which was estimated after they had known their teachers for six months. The conclusion is that there are interesting interactions between the gender of students and the gender of science teachers in high school along some dimensions. The statistical significant findings support the gender-stereotypic notion, while there are also tendencies supporting the gender-opposite notion. However, in most instances significant interactions between teacher gender and student gender are not established. The conclusion is more nuanced than in many earlier studies.

Keywords: Teachers' gender; teacher behaviour; student engagement; student achievement.

INTRODUCTION

In the research literature about the significance of teacher's gender we find – among many other distinctions - three important notions: *the gender-stereotypic notion*, *the gender-opposite notion* and *the gender-invariant notion*. *The gender- stereotypic notion* is that girls do better (across different school subjects) in classes taught by women, and boys fare better in classes taught by men (Noddings,1984). *The gender-opposite notion* implies that there are emotional bonds between the teacher and students of the opposite gender, yet it is difficult to find clear evidence of this (Einarsson & Granström, 2002). *The gender-invariant notion* is the idea that motivation, volition, academic work, engagement and attainment do not vary as a function of teacher gender. It is the nature of pedagogy that is influential and not the gender of the teacher delivering the instruction. Supporters of this hypothesis claim that there is only minor evidence to assert that a teacher's gender makes any difference to students' educational attitudes and attainment.

METHODS

The students responded to a survey that scored learning strategies; motivation/self-discipline; teacher conduct/class environment; teacher-student interactions; and parent engagement. In line with newer research about motivation, learning strategies and self-regulation, we have focused on subject specific aspects connected to a school subject, in this case science: (1) classroom management (2) exertion of academic pressure to learn in the classroom (that Norwegian school authorities wish should characterize the learning situation). Classroom interaction also demands that the teacher (3) handles social relations so that reciprocal relational trust is established. The study is done within the test theoretical paradigm where psychological constructs are measured by sets of individual questions (items) that are asked of the students. We discuss constructs that have worked sufficiently well from psychometric quality criteria. The questionnaire consisted partly of already established measurement instruments that were adjusted to a science subject context, and partly of newly developed instruments based on a pilot study that was implemented in fall 2006. Students were asked to answer the items using the five-point Likert-scale from totally disagree (1) to totally agree (5). In the analysis, we compare average values for girls and boys being taught by their respective female or male science teachers.

RESULTS

The results show that boys evaluate their own grade levels significantly higher than girls do in science. However, the difference is correspondingly large within the two groups of students taught by female and male teachers, respectively. When it pertains to the constructs connected to student engagement, we find statistically significant gender differences in the groups for 6 of 14 tests. Regarding the construct of mastery motivation,

there are no gender differences found in the group with female teachers, but there are, however, a significant difference in the group taught by male teachers. The comparison of values in the group with female science teachers shows that the values for girls taught by male teachers are somewhat higher, but they are somewhat lower for boys. In other words, we found indications of interactions between teacher and student gender along the lines of the gender-opposite notion. However, it is important to note that none of the interactions between teacher and student gender among the constructs in this category are statistically significant. One should, therefore, be very careful regarding the possibility of capitalising on chance when interpreting these findings. Boys show tendencies to experience the teacher's exertion of classroom management more effectively with male teachers, while girls experience this aspect somewhat more positively with female science teachers. Furthermore, there are tendencies that girls experience a teacher's ability to build reciprocal trust more positively by female teachers, while boys experience

male teachers more positively here. Here we find a significant interaction effect between teacher gender and student gender ($p<0.05$). This finding, in other words, supports the gender-stereotypic notion. The results for the construct *Disengagement* show that boys react significantly less negatively under pressure when relating to male science teachers. Here we find a statistically significant interaction effect between teacher and student gender $p<0.05$). There is also a weak tendency for girls, to a larger degree, to want pressure to learn and control when they are taught by female science teachers, and boys responded correspondingly when they had male science teachers. The interactions in this category, in other words, point to the gender-stereotypic notion. The last category of constructs deals with parental influence. It is naturally easier for students to distance themselves from their parents as they grow older. The results show that girls who are taught by male science teachers report a significantly greater involvement from parents than girls taught by female science teachers. For this construct we find a statistically significant interaction effect between teacher and student gender ($p<0.01$). If we interpret this as compensatory behaviour displayed by parents and students, we have an example of gender-stereotypic notion. However, it has to be underlined that also other interpretations are possible regarding this point.

CONCLUSION

We find support for the gender-invariant notion in most instances. However, the three statistically significant interaction effects between teacher and student gender are all in line with the gender-stereotypic notion. Furthermore, we find tendencies supporting the gender opposite notion in some instances (Mastery motivation, Influencing performance norms in class). However, these interactions between teacher and student gender are not statistically significant, and very careful interpretations are therefore needed. Implications of these findings will be elaborated in the presentation.

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THE COGNITIVE LEVEL OF THE QUESTIONS IN THE SECONDARY CHEMISTRY TEXTBOOKS AND THE OPINIONS OF STUDENTS AND TEACHERS ABOUT QUESTIONS

Sinem UNER

Gazi University
sinemuner@gazi.edu.tr

Huseyin AKKUS

Gazi University
akkus@gazi.edu.tr

ABSTRACT

In developing thinking skills, the role of the questions is immense. In this study; the cognitive level of the questions in 9^{th} and 10^{th} grade chemistry books are examined according to Bloom's taxonomy. Also, the opinions of students and teachers about questions in textbooks are determined. This study was conducted with 88 chemistry teachers who worked in 58 secondary schools and 1165 students in 2008-2009. The results of the study reveal that; i) textbooks highly involve lower cognitive level questions. ii) students aren't interested in questions. iii) variety of questions and different levels of cognitive domain aren't included in textbooks.

Keywords: *Bloom's taxonomy, textbook, question analysis*

INTRODUCTION

The questions which are on the higher order cognitive level lead students to question and think in higher levels (Hotiu, 2006). The fact that the students face with the questions which assess not only their learning at the same level, but also their learning at different levels will help them in gaining higher order thinking skills (Karamustafaoğlu et al., 2003). In a study carried out by Davila and Talanquer (2010), it was found that textbooks highly involve application level questions. In their study, it was found that synthesis and evaluation levels of cognitive domain were used nearly with the proportion of 5% in three general chemistry textbooks. In a study conducted by Risner et al. in 1991, it was detected that there were many low level cognitive questions with the proportion of 60% in science textbooks and higher level of cognitive domain weren't used in the questions. The questions included in textbooks should be in a type that make students curious and encourage them to investigate. It is as important as the cognitive level of questions. In the textbooks the questions enabling students' critical thinking should be used.

The primary purpose of this study is to detect the level of the questions that are present in 9th and 10th grade chemistry textbooks according to Bloom's taxonomy. The secondary purpose of this study is to detect the opinions of the students and chemistry teachers about questions in chemistry textbooks.

METHODS

In this study, content analysis was used to determine the cognitive level of questions and survey design was used for students' and teachers' opinions. A questionnaire that was reliability factor was 0.82 and a criteria table for the analysis of the cognitive level of questions was used as a tool.

This study was conducted with 88 chemistry teachers who worked in 58 secondary schools in the 8 district of Ankara and 1165 9^{th} and 10^{th} grade students. In this study the cognitive level of the open-ended and multiple choice questions in chemistry textbooks that belong to years that was used in 2008-2009 fall and spring semesters were examined according to Bloom's taxonomy.

The cognitive level of the questions used in chemistry textbooks was examined by the researchers and a graduate student by using a criteria table. The criteria table was formed by the help of the related literature in order to determine the cognitive level of 286 questions in textbooks. It was composed of the objectives of the cognitive domain, keywords to determine the cognitive level of the questions and chemistry questions that could be used to determine the cognitive level of the questions. It was controlled by the experts in chemistry education to determine whether it was appropriate for the study or not.

A Likert-type scale was formed by the help of the related literature in order to get the opinions' of the students and teachers about the questions used in the textbooks. Content validity of the questionnaire was assessed by the experts in chemistry education and the internal consistency of the questionnaire was found 0.82 by using Cronbach alpha. In the questionnaire students and teachers were asked whether they found the level of the questions appropriate and interesting and whether they found variety of the questions adequate or not. Also they were asked whether they found variety of the questions adequate or not.

RESULTS

When examined the distribution of the cognitive level of the questions, it is found that knowledge level questions are used on the 9th grade chemistry textbook with the proportion of 29% and application level questions are used on the 10th grade chemistry textbook with the proportion of 83%. It is detected that higher levels of the cognitive domain are used on the 10th grade chemistry textbook with the proportion of 7%. Also 20% of 9th and 34% of 10th grade students stated that they never compare with curious and interesting questions. When examined the distribution of the teachers' opinions; it is stated that the level questions aren't enough to develop higher order thinking skills for 45% of them, variety of questions and different levels of cognitive domain aren't included in chemistry textbooks for 50% of them.

CONCLUSIONS

Considering the results of this study, it can be concluded that by using higher cognitive level questions more on textbooks, the higher order thinking skills of the students can be increased. So the questions can be more interesting and challenging for them. Because of this it is proposed to use higher order thinking skill questions more in textbooks.

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DEVELOPMENT OF A QUESTIONNAIRE MEASURING PRIMARY SCHOOL TEACHERS' ATTITUDES TOWARDS SCIENCE AND TECHNOLOGY

Sandra I. van Aalderen - Smeets

University of Twente, The Netherlands

sandra.vanaalderen@utwente.nl

Juliette H. Walma van der Molen

University of Twente, The Netherlands

j.h.walmavandermolen@gw.utwente.nl

Lieke J.F. Asma

University of Twente, The Netherlands

l.j.f.asma@gw.utwente.nl

ABSTRACT

Existing instruments designed to measure primary teachers' attitude towards science and technology often poorly define the complex construct of attitude resulting in unreliable and non-interpretable measurements. The construct-validity of the instrument presented here is achieved by a thorough theoretical underpinning of the construct of attitude. The result is a comprehensive framework consisting of relevant components of attitude which is used for the development of the instrument. An important distinction is made between teachers' personal attitude towards science and technology and their professional attitude towards the teaching of these subjects. Both the conceptual framework and the instrument will be presented.

Keywords: *Attitude; science & technology; teacher education; Primary school teachers; Questionnaire development.*

INTRODUCTION

The study on attitudes towards science and technology has received considerable research attention over the last decades. Its importance is emphasized by the growing evidence of a decline in the interest of young people to pursue a scientific career, research indicating the scientific ignorance of the general public, and an increasing recognition of the importance of scientific knowledge (Osborne, Simon and Collins, 2003). Most students have already excluded the choice of a science or technology study during their primary school period (Osborne and Dillon, 2008). Crucial in determining positive attitudes of students in their primary school period are school teachers (Harlen and Holroyd, 1997). However, the attitudes of (pre-service) primary school teachers towards science and technology are mostly negative (Harlen and Holroyd, 1997). This is problematic because these teachers spend less time on these topics in their classroom, rely more on standardized methods and top down instruction, and are less able to stimulate students' attitudes. From the above, it follows that explicit attention to the attitudes of (pre-service) primary teachers towards science and technology is of fundamental importance for the professionalization of these teachers within the science and technology domain (Haney, Czerniak, and Lumpe, 1996).

Although such attitudes have been investigated in a range of scientific studies, scientific progress in this field remains slow due to several major theoretical and methodological issues (Bennet, Rollnick, Green, and White, 2001). Most importantly, both in research and in educational change projects the concept of an attitude towards science is often poorly articulated. Many reported studies do not, or incompletely, theoretically define the construct or they do not articulate the different components of attitude that they are measuring. In addition to (and also because of) the poor theoretical definition of what constitutes teachers' attitudes towards science and technology, many studies use measuring instruments that are poorly designed. The instrument construction and construction of individual items is poor and many studies fail to pilot-test, validate and evaluate the instrument according to the current psychometric standards. These two methodological problems have several consequences. First, interpreting results is difficult because it is not clear what is actually being measured. Second, comparing results between studies is hard due to the fact that these studies measure different aspects, components or objects of attitude. Thus until now no review compared studies on the basis of what was actually measured.

This presentation will show the development of an instrument to measure primary teachers' attitude towards (teaching) science and technology. We will remedy the issue of poor theoretical definition of attitude by trying to disentangle the construct in a theoretically sound manner. In order to do so a comprehensive overview of components relevant to the construct of attitude towards (teaching) science and technology is composed based on theory and literature. These components form a conceptual framework that will be used to organize the multitude of different attitudinal concepts that have been measured in previous research and will incorporate these concepts when relevant. The instrument presented here is based on the conceptual framework and will be validated using quantitative methods. This presentation will show the different development steps and the resulting instrument.

METHODS

The framework for the construct of attitude was based on relevant theoretical models of attitude. This framework was used as a filter to select all possible components and attributes of attitude that have been measured in the research on attitudes towards science and technology over the last 25 years. In addition to this extensive theoretical underpinning of the construct of attitudes, semi-structured interviews were held with 71 preservice or inservice primary teachers asking these teachers about their personal attitudes towards science and technology in general, but also about their professional attitudes towards the teaching of science and technology. Based on the conceptual framework and results from interviews an instrument was developed to measure primary teachers' attitudes towards (teaching) science and technology. The instrument was pilot-tested using quantitative (factor analysis) and qualitative methods (feedback from (preservice) teachers).

RESULTS

Results from factor analysis and interviews support the relevance of the framework for the development of the instrument. Factor analysis reveals a factor structure which supports the structure of the framework. In addition, the factorial structure for personal attitude and professional attitude was comparable, although emphasizing different accents. Feedback from teachers supported the distinction made between personal and professional attitude.

These results are promising for successful development of the instrument and provide useful suggestions and considerations for future work on validating the instrument.

CONCLUSIONS

The framework presented here proved a successful tool for the development of an instrument, but also for the comparison and review of previous studies on attitude towards science and technology. Central to the framework for the construct of attitude are cognitive beliefs and affects. These components are flanked by the concepts of self-efficacy, perceived context factors, locus of control, and interest, which have proven to be indispensable concepts when investigating attitudes. An important distinction present in theoretical models, but not instruments, concerned the difference between a teachers' personal attitude towards science and technology and that persons' professional attitude towards the teaching of science and technology. The relevance of distinguishing between these attitude objects is also supported by the results from the interviews. This conceptual framework proved to be a solid underlying theoretical base for instrument development. We therefore conclude that the resulting instrument has shown to be a promising tool for measuring teachers' attitudes towards (teaching) science and technology.

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A STUDY OF THE EFFECT OF APPLYING A SPIRAL LEARNING AS A TEACHING MODLE ON ACADEMIC CONCEPTS LEARNING AND SOCIO-CULTURAL& HUMAN VALUES OF IRANIAN STUDENTS

Fahimeh Veladat

SCIENCE AND RESEARCH BRANCH OF ISLAMIC AZAD UNIVERSITY, DEPARTMENT OF EDUCATIONAL ADMINISTRATION

fahimeh_veladat@yahoo.com

Behrangi, Mohammadreza

IOSTE REGIONAL OFFICE FOR COUNTRIES AROUND PERSIAN GULF SCHOOL OF PSYCHOLOGY AND EDUCATION,DEPARTMENT OF EDUCATIONAL ADMINISTRATION,TARBIAT MOALLEM UNIVERSIT TEHRAN-IRAN

Behrangimr@yahoo.com

ABSTRACT

Spiral learning teaching model is one of the active teaching models with 11 steps and 15 objectives. At first, the plan was implemented on a 15-person pilot and an evaluation was conducted by Behrangi's questionnaire. The type of this research is practical and the research method is field study and Cronbach's Alpha test is used for evaluating internal similarity in pilot part in which the results show high similarity of different items. Then the scenario will be performed for 54 university students, whom their assessment will be analyzed by application of the 72-item questionnaire based on objectives through a nonparametric statistical and unidirectional chi Square test and SPSS.

Keywords: *Teaching models; spiral learning; effective education; human values; Socio-cultural values.*

INTRODUCTION

Humans communicate with environment by their five senses and they use these five senses with respect to their needs. Some research showed that 75% of learning has been developed by visual sense and 13% of that is developed by hearing sense and these results show the importance of these two senses in human and also these senses lead to 88% of learning in individuals. We tried to increase learning with involving visual and hearing senses in this model.

METHODS

In the first step, learners achieve teacher's mental concepts through using audio-visual clips, then they will be divided into groups and teaching will be continued by asking individual and collective questions. Finally, learners write down important items and submit them to the teacher; on the next session, written notes will be returned back to the learners to be reviewed and subsequently, the teacher corrects them and mentions important issues on that regard to learners Steps of spiral learning model: this model includes 11 steps and it is called spiral learning because of continuity of the steps and those steps are:

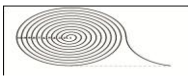

Diagram 1 . model of spiral learning

1) Audio-visual clips 2) Teacher's question 3) Learner's answer 4) Grouping 5) Individual and collective questions of teacher (accompanying with image and sound) 6) Freedom of mind 7) Writing what have been learnt 8) Comprehensive Study 9) Revise and review notes 10) A teacher's conclusion 11) A feeling of satisfaction.

GOALS OF TEACHING THE SPIRAL LEARNING

The given model consists of 15 goals that are measured and analyzed by a questionnaire, the goals are not offered on the basis of their importance or priority, however they are considered important goals according to the researchers and play a major role on application of this model. These goals are: 1-Conceptualization 2-Creativity 3-Team work (Synergy) 4-Individual work 5-declaring thoughts and achieve a hypothesis 6-Familiarity with terms 7-Applying images 8-Knowledge 9-Interpreting and critique 10-Learning 11-Connect unfamiliar concepts With familiar ones 12-Feel trust 13- Extending information and the capability to maintain 14-Pre-Organizer 15-Scientific thoughts

RESULTS

In this research, 15 students of Sciences and Research University in the field of educational management are studied in learning environment and they have considered teaching process in order to evaluate the effect of this model on learning of learners and finally, educational effects of this model is investigated by standardized questionnaire of Dr.Behrangi and internal similarity of variable was calculated by Cronbach's Alpha and this was 0.96. To control the variables and to avoid the effect of teacher on group, students of educational management for semester of 1999 and 2009 in M.A degree of Azad management and economic university of sciences and research ministry have conducted an opinion poll by presenting seminar and questionnaire. Type of research is practical and research method is field study; descriptive statistic test (frequency and percentage) and nonparametric statistical and unidirectional chi Square test is used to evaluate the significance between the opinions of persons. Whereas the questionnaire has 72 items, each item is analyzed and they are shown in the following table.

Question number	Sig level	Chi-square	Question number	Sig level	Chi-sqare	Question number	Sig level	Chi-square
1	0.00	24.11	25	0.04	6.33	49	0.00	30.33
2	0.00	18.77	26	0.084	0.33	50	0.001	14.33
3	0.00	19	27	0.6	1	51	0.12	4.11
4	0.00	16.33	28	0.21	3.11	52	0.003	11.44
5	0.006	10.33	29	0.00	21	53	0.005	10.77
6	0.00	26.77	30	0.00	16.44	54	0.00	16.33
7	0.001	14.11	31	0.001	14.33	55	0.00	24.11
8	0.00	33.44	32	0.00	22.33	56	0.002	12.11
9	0.006	10.11	33	0.00	20.33	57	0.22	3
10	0.00	17.33	34	0.00	25.44	58	0.06	10.33
11	0.00	21	35	0.00	16.33	59	0.22	3
12	0.04	6.33	36	0.03	6.77	60	0.001	14.11
13	0.00	16.44	37	0.003	11.44	61	0.11	4.33
14	0.002	12.11	38	0.1	2.66	62	0.03	6.77
15	0.00	19.11	39	0.00	30.33	63	0.12	4.11
16	0.009	9.33	40	0.00	30.33	64	0.31	2.33
17	0.00	21	41	0.00	18.77	65	0.06	5.44
18	0.00	16.33	42	0.00	16.77	66	0.01	8.77
19	0.00	28.77	43	0.001	14.11	67	0.06	5.44
20	0.00	27.44	44	0.01	8.77	68	0.01	8.11
21	0.06	5.44	45	0.00	37.33	69	0.00	19
22	0.00	24.11	46	0.00	21.77	70	0.00	17.24
23	0.00	35.11	47	0.00	15.88	71	0.00	18.77
24	0.001	14.77	48	0.00	22.11	72	0.00	17.44

CONCLUSIONS

Spiral learning model is not separate from other teaching models but it may make a new and incorporated view of them. In our questionnaire, we considered 72 ideal speeches and our goal is to reach them and these speeches indicate our ideal and expected condition. For this reason, when the questionnaire is generalized to the university, speeches were analyzed to evaluate the ideal condition and current condition and also investigating the opinions of people using chi Square test and the results show that we are approaching to ideal and favorite condition which we were expecting.

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INTERDISCIPLINARY EDUCATIONAL APPROACH TO THE SCIENCE OF HUMAN VOICE

Ivo Verovnik

National Education Institute of Slovenia

ivo.verovnik@zrss.si

ABSTRACT

Human voice and spoken language are the most important means of everyday interpersonal communication. Despite this fact the scientific background of human voice production is often neglected in school curriculums. There are several reasons for such a situation. The structure of speech organs and the mechanism of voice production are relatively complicated and the scientific explanation of these processes requires an interdisciplinary approach. There is also a lack of didactic materials to support this type of lessons. The developed didactic aids for this purpose using powerful electronic and computer technology, which is nowadays available also to the teachers and students, will be presented.

Keywords: *human voice, speech organs, interdisciplinary, didactic material, computer technology.*

INTRODUCTION

From historical point of view, sound was already an important field of scientific research especially in previous centuries. In recent years a big step forward has been made in this sphere of activity by the development of computer technology. Contemporary information and communication technology enables processing of huge amount of data, which is needed to store and analyse sound records of a human voice.

Efficient computer technology is today available also in schools and school laboratories. What was once very expensive equipment, which was available only to the well equipped acoustic laboratories, can be used today widely by the teachers and students.

School teachers can plan and prepare their lessons in more attractive way for the students, especially when taking into account the fact that singing voice and music as a special sound phenomenon, is one of the most important means of entertainment in our everyday life.

Despite the fact that human speech and hearing is still the most important for our interpersonal communication, in school curriculums the scientific background about these phenomena is often neglected. The main reason for this situation is on one hand the complexity of the scientific background about speech and hearing and on the other hand there is an absence of suitable didactic supporting material.

METHODS

Examples of the developed didactic material about sound, human voice and hearing, based on the use of computer technology, will be presented. One can find more detailed description of this material in the references. A lot of different software can be used for editing and analyses of sound records. Some of them are professionally designed and relatively expensive (Adobe Audition), but there are also free and open source programs, which can serve for the same purpose (Audacity).

The different vowels used in human speech are produced in vocal tract, starting roughly at the vibrating vocal cords in larynx and ending at the lips. This is done mainly by changing the shape of the vocal tract and consequently its resonant frequencies are changing. Some of the overtones are reinforced with respect to the different resonances of the vocal tract. The mechanism is relatively complicated to understand so that interactive electro-mechanical model helps in understanding the basics. The corresponding experiment, showing synthesized production of different vowels will be presented.

RESULTS

The core of the developed material is included in the book Acoustische Phänomene (Mathelitsch & Verovnik, 2004) together with enclosed CD-ROM containing the selected sound files, discussed in the book.

More than hundred sound examples from CD-ROM can easily be played in a classroom. The computer technology allows that sound files can be analyzed on a computer, for instance, with regard to their spectral content.

The book contains short explanations of the sound examples and of the underlying sound-production mechanisms. It can therefore also be used as a kind of encyclopaedia, offering information on specific sound phenomena.

CONCLUSIONS

The aim of the developed didactic material is to make explaining the production and characteristics of different voices representing the basic of all spoken languages easier and more effective. The presented interdisciplinary educational approach has an important meaning also in the sense of linking the contents from different school subjects such as physics, biology, mathematics, informatics, languages and music.

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Adobe Audition: http://www.adobe.com/products/audition, Audacity: http://audacity.sourceforge.net/

UNDERSTANDING OF THE CONCEPTS OF OSMOSIS AND DIFFUSION BY PRE-SERVICE PRIMARY SCHOOL BIOLOGY TEACHERS

Tatjana Vidic

Simon Jenko Primary School Kranj/
Ul. XXXI. divizije 7a, Kranj

tatjana.vidic@gmail.com

Iztok Tomažič

Biotechnical Faculty, Department of Biology/
Večna pot 111, 1000 Ljubljana

iztok.tomazic@bf.uni-lj.si

ABSTRACT

The concepts of diffusion and osmosis, which students encounter in different biology courses, are closely related to certain concepts of physics and chemistry. Both however may pose a difficult challenge to students, when it comes to their understanding. In our study, a modified two tier Diffusion and Osmosis Diagnostic Test (DODT) was administrated to pre-service teachers. In addition, we asked the prospective teachers if they had conducted any experiments regarding either of the concepts in high school to determine whether this could affect their performance in the test. Results suggest that students generally lack thorough understanding of the two concepts, which is consistent with the findings of previous studies. We also found that students who had conducted experiments with diffusion and osmosis in high school achieved better test scores than students who did not have, or did not recall having this experience.

Keywords: *diffusion, osmosis, pre-service teachers, understanding*

INTRODUCTION

The concepts of diffusion and osmosis are important for understanding life processes. They are introduced in many biology courses (e.g. general biology, cell biology, physiology, ecology). They are also closely related to concepts of physics and chemistry, such as permeability, solutions, and the particulate nature of matter (Friedler et al., 1987).

Researchers report that students generally have many inaccurate conceptions and misconceptions about diffusion and osmosis, and that they find these two concepts difficult to differentiate (Friedler et al., 1987; Friedrichsen & Pallant, 2007). Odom and Barrow (1995) believe that students have difficulties with the concepts of diffusion and osmosis because: (1) formal reasoning skills are required to understand these two processes, (2) making sense of these constructs subsumes understanding of other technical concepts, e.g. solution, solute, solvent, semi-permeability, molecular movement, net movement and direction of movement, and (3) there is often confusion between the vernacular and scientific usages of terms, e.g. pressure, concentration and quantity. In our study, we assessed pre-service primary school biology/home economics and biology/chemistry teachers' understanding of diffusion and osmosis. In addition, we compared test scores according to the year of study, study programme and whether or not the students had done experimental work on the two concepts in high school.

METHODS

A total of 168 first, second and third year pre-service teachers completed the modified Diffusion and Osmosis Diagnostic Test (DODT) that consisted of 12 two-tier items (Odom & Barrow, 1995). The questions were multiple-choice. The first tier required content and the second tier required a reason for the first response. In our version of the questionnaire, we changed two questions. Split-Half Reliability of questionnaire was 0.73 and difficulty of questions ranged from 10% to 89%.

The research was conducted in three academic years (2007/2008, 2008/2009 and 2009/2010). Altogether, there were only 10 (6%) male students. Students were also equally distributed according to study programme and year of study (χ^2=0.668, df=2, p=0.716). The majority of the students finished gymnasium (n=156; χ^2=0.681, df=2, p=0.712). The average age of first year students was 19.3 (SD = 1.1) years, while the averages for second and third year students were 20.6 (SD = 1.2) and 21.9 (SD = 1.3) years, respectively. In addition, we asked students whether they had conducted any experiments regarding the concepts of diffusion and osmosis in high schools in order to find any differences in their knowledge. 163 students answered this question. 32% of first year, 48% of second year and 36% of third year students stated that they had conducted such experiments in high school (χ^2=3.958, df=4, p=0.412).

RESULTS

In the first tier of the test, the range of correct answers for first year students ranged from 16.7% to 83.3%, for second year students from 16.7% to 100%, and for third year students from 41.7% to 91.7%. When both tiers were combined, the correct responses were significantly reduced to the range of 0% to 38.9% for first year students, 0% to 61.1% for second year students and 0% to 55.6% for third year students. There were statistically significant differences between the averages of students' correct answers for the first tier across different years of study; ANOVA: $F(2,165) = 17.21$, $p < 0.001$). The same applied for average correct answers of both tiers combined; ANOVA: $F(2,165) = 15.53$, $p < 0.001$). Differences were present on account of first year students, whose achievement was significantly lower than the achievement of second and third year students (Tukey HSD: $p < 0.001$). Given these facts we can conclude that the knowledge about the two concepts students may have gained in high school was superficial.

When we analysed students' answers according to whether or not they had conducted experiments about the two concepts in high school (*Yes / No / I don't remember*), we found statistically significant differences in the average students' achievement scores on the first tier (ANOVA: $F(2,160) = 7.57$, $p = 0.001$) and on both tiers combined (ANOVA: $F(2,160) = 5.33$, $p = 0.006$). On the first tier, multiple comparisons test (Tukey HSD) showed that the main difference was on account of students who reported that they had conducted experiments regarding diffusion and osmosis in high school ($p = 0.002$ for yes/no comparison, $p = 0.009$ for yes/don't remember comparison, and $p = 0.765$ for no/don't remember comparison). But when we compared results from both tiers combined, the main difference was found between students who stated that they had and those who had not conducted experiments about diffusion and osmosis in high school ($p = 0.004$ for yes/no comparison, $p = 0.465$ for yes/don't remember comparison and $p = 0.100$ for no/don't remember comparison). Results from the first tier indicate that conducting experiments in high school could be the reason for the better achievement of some students. But the results for both tiers combined do not yield an identical conclusion, as described before. Namely, the results of students who had conducted experiments in high school did not significantly differ from the results of students who did not know (remember) whether they had conducted experiments.

CONCLUSIONS

Results suggest that students generally lack thorough understanding of diffusion and osmosis, which is consistent with the findings of previous studies. Higher-year students showed better understanding of both processes, although not as high as we had anticipated. Results indicate that conducting experiments in high school could be the reason for the better achievement of some students. Further research is needed to gain a more detailed insight into factors that may or may not influence the comprehension of the said two concepts.

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THE PRESENTATION OF S&T-SCIENTISTS IN NORWEGIAN NEWSPAPERS

Kristoffer Barbøl Vikebak

Faculty of Mathematics and Natural
Sciences
University of Oslo

k.b.vikebak@matnat.uio.no

S&T-SCIENTISTS IN NEWSPAPERS

It is assumed that the presentation of scientists in media influences the perceptions youth have of educations within science and technology (S&T), thus influencing the education choices youth make. The presentation of media sources holding higher degrees in science and technology. Norwegian newspapers has therefore been the subject of study in a Master's Thesis in Media Science. By combining quantitative and qualitative content analysis, the study revealed that newspapers portrayed S&T-scientists as focused on their area of research, and when moving away from it, their connection to S&T-subjects becomes more unclear.

Keywords: *Educational choices*, *Role models, Science journalism.*

INTRODUCTION

The processes that lie behind youth's choice of education are many and complex. Family, friends and talents are of great importance (Ramberg, 2006). So is the media, both when it comes to entertainment in media and the news. News media are in many ways people's eyes to the world outside and the way in which they present S&T-scientists has a great impact on what kind of impression youth have of scientists. As a result, news media may influence the choices youth make when it comes to choosing an education.

THEORETICAL FRAMEWORK

Educational choices are in the late modern society more a choice of who you want to be than what you want to be (Giddens, 1991; Schreiner, 2006). Youth's choice of education becomes a choice of identity and the impressions they have about different professions influence their choices greatly. Their impressions are therefore of importance when choosing an education (Schreiner, 2006). Norwegian youth generally find S&T-educations uninteresting as a career alternative (Schreiner, 2006).

Newspapers are often the starting point for news, and other news media get their news from newspapers (Lund, 2000). Despite the general decrease in circulation, newspapers are still one of the main bearers of news. The presentation of S&T-scientists in newspapers is therefore of importance when it comes to the choice regarding education youth make.

METHOD

The three cases examined were chosen because they got major media coverage and were closely related to S&T-subjects. The cases, the landslides in Bergen in 2005, the Climate Settlement during the winter of 2008, and the start-up of the LHC-experiment in CERN in the autumn of 2008, generated over 500 newspaper articles. These articles were subject to a quantitative content analysis. A strategic selection of articles was made based on the results of the first analysis. 48 articles were thus selected for qualitative content analysis with focus on the presentation of S&T-scientists.

The discoveries from this analysis were viewed in the light of science journalism studies, among others Esa Väliverronen's (2001) study of media's use of scientists as sources.

RESULTS AND DISCUSSION

S&T-scientists don't usually play the main role in the news, but when they do, their focus lies mainly on the subject area they are an expert on. Instead, S&T-scientists could have chosen to focus on the broader aspects of their subject field, thereby showing why and how they are important to society. The strong focus on the subject area in itself creates a portrait of the S&T-scientist in the news as less appealing. This is especially the case for younger readers who aren't being made aware how S&T-subjects actually relate to themselves and their own identity.

When S&T-scientists in the news move away from the subject area in itself, it is difficult to see that they are in fact S&T-scientists, contrary to politicians who are clearly politicians even when they address areas that are not particularly political. The reason for this may be that being a S&T-scientist is an unclear role to play. And this is clearly reflected in the news.

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A SOUTH AFRICAN PERSPECTIVE FOR IMPROVING LEARNERS' FUNDAMENTAL SENSE OF SCIENCE: AN INTEGRATED TEACHING STRATEGIES APPROACH

Mary Grace Villanueva
Nelson Mandela Metropolitan University
marygrace.villanueva@nmmu.ac.za

Paul Webb
Nelson Mandela Metropolitan University
paul.webb@nmmu.ac.za

ABSTRACT

In light of South Africa's learner performance on international and national assessments such as TIMMS (2003) and PIRLS (2006), as well as the problems of teaching and learning in a second language, there appears to be a primary and pressing need to develop learners' fundamental sense of scientific literacy. Expanding learners' ability to read, write and communicate in science may provide the necessary framework for engaging learners in the critical principles and foundations of the scientific endeavour. As such, this study focuses on equipping grade six and seven science teachers with a strategy that supports reading, writing, talking and 'doing' science through scientific investigations. The study was conducted in two different milieus in the Eastern Cape, South Africa. Quantitative data were collected from the baseline and post-intervention testing of learners' problem solving skills, as well as their literacy skills in English and isiXhosa. Qualitative measures were generated through classroom observations, teacher interviews and learners' science notebooks. The data suggest that the scientific literacy strategy improved the experimental learners' problem solving skills. Progression of learners' literacy skills varied according to each milieu. Teachers' gradual improvements in the use of the model suggest that they were able to use the strategy to support the cognitive and linguistic development of second-language learners.

Keywords: *Scientific literacy; general literacy; reading-to-learn science; writing-to-learn science; classroom discussion; argumentation; scientific investigations; inquiry-based teaching*

INTRODUCTION

In South Africa, science and mathematics teachers face the double challenge of working within the instructional framework of English while their learners are still developing their skills in this language (Setati, Adler, Reed & Bapoo, 2002). As a result, learners' reading, listening, speaking and writing skills in both their first language and English is usually poor (Mayaba & Webb, 2009). Research into educating second language learners affirms that teachers are required to define language and content objectives, as well as plan activities, which are experiential, hands-on, collaborative/cooperative, context embedded and cognitively engaging (Met, 1998; Cummins, 1981). Accordingly, an integrated teaching strategies approach was developed for the dual purposes of providing a pedagogic model for science teachers to implement in their classrooms and to promote learners' scientific literacy in the fundamental sense. The strategy used in this study synthesises various pedagogical approaches such as reading, writing, talking and arguing in science, as well as the 'doing' aspect of conducting investigations. This study investigated whether teachers were able to use the strategy for promoting scientific literacy for second language learners. Furthermore, the study examined what effect the strategy had on the way children engage in the processes and procedures required for scientific investigations, as well as the effect on learners' problem solving and general language and literacy abilities.

METHODOLOGY

The typology of triangulation and the mixed method research approach was supported by a fully mixed, concurrent, and equal status design (Leech & Onwuegbuzi, 2007). Quantitative data were collected from the baseline and post-intervention testing of learners' problem solving skills, as well as their literacy skills in English and isiXhosa. Qualitative measures were generated through classroom observations, teacher interviews and learners' science notebooks. The study was conducted in two different milieus in the Eastern Cape, South Africa. The first setting, in the rural area of Tyumie Valley near the Hogsback Mountains, was comprised of a sample of grade six and seven (multi-grade classrooms) teachers (n=7) and learners (n=168) from five experimental schools and two comparison schools. The second setting, in the urban townships area east of Port Elizabeth, was comprised of a sample of grade six teachers (n=8) and learners (n=675) from six experimental schools and two comparison schools. Mean differences between the experimental and the comparison groups were computed for the Raven's Standard Progressive Matrices (RSPM) and the literacy tests, and the data generated were treated with an Analysis of Covariance (ANCOVA).

RESULTS AND CONCLUSION

The data suggest that the scientific literacy strategy improved the experimental learners' problem solving skills. Both experimental groups demonstrated greater gains than that of the comparison schools; however, statistically significant improvements were only detected in Port Elizabeth. Improvements in learners' literacy skills in isiXhosa and English varied according to each milieu. While the teachers initially identified challenges to learners' reading and writing abilities, the analysis of learners' science notebooks suggested that they used writings to support their investigations. Some teachers cited difficulties with certain aspects of the model, such as problems with developing an investigable question and argumentation, yet overall, teachers found the strategy useful for developing learners' language skills, as well for strengthening their pedagogical practices in science. Teachers' gradual improvements in the use of the model suggest that they were able to use the scientific literacy strategy to support the cognitive and linguistic development of second-language learners.

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UNDERGRADUATE STUDENTS' TRAINING TO ATTEND THE VISITORS OF THE PROGRAMS OF EXPLORATORY SCIENCE MUSEUM - UNICAMP: A SUCCESSFUL EXPERIENCE

Adriana Vitorino Rossi

UNICAMP, Museu Exploratório de Ciências, Director of Education

adriana@iqm.unicamp.br

Fabiana dos Santos Toledo

UNICAMP, Museu Exploratório de Ciências, Supervisor of Educative Sector

fabianadossantostoledo@gmail.com

ABSTRACT

The interaction of all aged people with science in non formal education spaces such as museums can be facilitated by mediation conducted by specially trained people. The Exploratory Science Museum - UNICAMP trains undergraduate students from every different courses to work as mediators in its two major programs focused on hard sciences. The rich contributions from all these different areas of expertise provide an interdisciplinary character that improves the public attendance. Since 2008, we have trained a group of c.a. 60 mediators from 26 courses. Evaluation data show the correctness of this proposal of mediators training and forming staff.

Keywords: *non formal education, undergraduate students' motivation, science for all.*

INTRODUCTION

The purpose of Exploratory Science Museum - UNICAMP is to promote the dissemination of the scientific culture, valuing the social life, the leisure and the accessibility, at an area which focuses on the formation processes of the science and the technology, its impact on daily life and the environmental developments. With this commitment, our mission is to be an area of education and public communication of science and technology as a social creation, approaching to contemporary and contextualized problems. (Firer et al, 2008). Currently we occupy a space of about 40,000 m² campus of Campinas, with a small administrative building and an exhibition area that is being revitalized from the structure of an old naked eye observatory.

The Museum was established institutionally before having a physical building in 2005 when the first 2 programs, "NanoAventura" and "Oficina Desafio" (see http://www.mc.unicamp.br) started to receive people. This was possible because these programs travelled between cities and schools. The "NanoAventura" is currently headquartered in the campus of Campinas and has a replica in the Catavento Cultural and Educational in Sao Paulo-SP (details on http://www.cataventocultural.org.br). The "Oficina Desafio" can still go to schools even in the other cities.

The interaction of the visitor public of museums with Science can be facilitated by mediation conducted by specially trained people. Although this service can be performed by professionals, our Museum has been invested in training undergraduate students to act as mediators or guides for the public reception in our programs. Different names such as educators, mediators, facilitators, guides, hosts, entertainers, among other can be cited. Our Museum has mediators (in Portuguese *mediadores* or *monitores*) as we are used to call the very important group of undergraduate students who interacts directly with the visiting public. Although this service can be performed by professionals, our Museum has been made efforts in training undergraduate students to act as mediators for the public reception in our programs.

For now, the theme of our major programs in operation ("NanoAventura" e "Oficina Desafio") is focused on hard science and since 2005 more than 40,000 people had visited them. Initially, the attendance programs to the public were mediated mainly by students of physics and with increasing the numbers of visitors it was necessary to expand the number of mediators and improve the new mediators training course.

METHODS

In 2007, we started to organize an intensive course for training new monitors: an intense but pleasant programme of one week work. The number of mediators aspirants has increased by over 200 % since 2007 and the courses of origin of these undergraduate students has also increased. Initially, the training was focused on conceptual and operational aspects of the programs and it has gradually been improved by introducing different approaches to interact. We decided to call people with the most different professional/personal profile and distinct skills including scientists, doctors, educators, nurses, blind, deaf and dumb people and their interpreters. All they are invited to specially called lectures and interactive talks. The mediators in training have been expressing good acceptance to these diversified contacts on spontaneous demonstrations and posterior comments at evaluation interviews. Another important role of activities is the implementation of various cooperative games in order to motivate the students to start interacting as a cohesive group. Intensive first aid training is also included. The five days of training are followed by the senior mediators who enhance the activities as examples for inspiration and background on various aspects discussed.

Despite of the focus of our programs in hard sciences, the training of the mediators is following on the opposite direction: we have chosen the diversity of origin courses of the mediators as an option to diversify the profile of our staff. The valuable contributions from each one of the different areas of expertise provide an interdisciplinary profile to our staff that improves the public attendance. The number of undergraduate students interested in working as mediators increased almost 200 % and the number of origin courses of these students increased from 11 in 2007 to 27 in 2010, despite of the remaining emphasis on hard sciences in our programs. Pedagogy and teaching degree students are less than 30% of the mediator staff.

RESULTS

The regular evaluation tools of the programs of the Museum have been used to evaluate this proposal of staff training. With regard to the public attendance, spontaneous demonstrations of opinion have been reported during the activities and there also are answers to evaluation inquiries, including teachers' and parents' when they are present. The performance of all students is very positive without distinction by area or course.

It may be noted that among the undergraduate students, working at the Museum as mediators is a considered as a very stimulating activity which arouses a new insight about sciences that is not common at their formal teaching/learning situations. All this involvement promotes effective interaction with the visiting public and represents a very important motivational factor regardless of the mediators' origin course.

CONCLUSIONS

All results show the correctness of this proposal for training the mediators, which must include affective involvement as an important motivational factor in promoting higher interaction between the public and the Science.

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TARGETTING TALENT AND INVESTING IN THE EXCELLENCE OF SOUTH AFRICAN STUDENTS FROM RURAL AREAS

Ahmed A Wadee

School of Pathology, NHLS & University of the Witwatersrand

Ahmed.wadee@nhls.ac.za

Reverie H Kuschke

School of Pathology, University of the Witwatersrand

Reverie.kuschke@wits.ac.za

Zena Richards

School of Community & Human Development, University of the Witwatersrand

zena.richards@wits.ac.za

Loyiso Nongxa

University of the Witwatersrand

Loyiso.Nongxa@wits.ac.za

ABSTRACT

The Targeting Talent Programme aims to increase academic and non-academic preparedness of learners from socioeconomically disadvantaged backgrounds for admission and success at South African universities. Learners were selected from rural sites on the basis of nominations, biographical questionnaires and grade 9 promotion reports providing an avenue to access tertiary education.

Learners and their teachers were exposed to the university environment over a three year period (two week blocks) which included instruction in science, mathematics, personal skills development and mentor support.

This presentation addresses the success of the programme for allowing access to tertiary education and assessment of performance at university.

Keywords: *targeting talent; rural students; access to tertiary education; academic enrichment; opportunity.*

INTRODUCTION

The Targeting Talent Programme aimed to increase the academic, social and psychological preparation of academically talented learners through a four phase approach. The first phase involved conceptualisation and securing funding; the second identify the academically talented learners; the third phase undertook to design and implement academic enrichment, personal developmental skills residential; educator development and mathematics and science redress curricula. The current and fourth phase is to evaluate student acceptance at tertiary level and their academic performance in the first semester at university in 2010.

It is intended to present data indicating the number of admitted students and their initial academic success following our intervention. Students without such support have not gained admission to tertiary institutions or have performed poorly when admitted.

METHODS

The selection of youth with high potential to succeed academically therefore used a benchmark of achieving at least 65% in Mathematics, Science and English. To this, was added evidence of traits or behaviour patterns believed to correlate with academic success (as evidenced in the nomination form and the biographical questionnaire. Academically, learners with scores of 73% (average) in the three subjects were ultimately selected. In total 267 learners and 54 educators from the various schools were exposed to the programme. Following preparatory workshops with prospective participants, parents/guardians and educators held in the three provinces in May and June of 2007, 2008 and 2009 Participants were also exposed to various aspects of the University environment including residence. Initially learners and teachers were exposed to setting baseline parameters, an instructional phase that included specific instruction, including practical laboratory involvement and extracurricular activities. Learners and teachers were enlisted in a University residential academic enrichment, personal skills development and a mathematics and science redress curriculum. All learners had exposure to a mentoring programme whereby current university students participated as mentors and role models and were with their respective groups throughout the period.

RESULTS

Of 267 learners taking part in the programme,12 were unsuccessful at Grade 12 level but 219 (82%) achieved eligibility for admission to university and others were eligible for non-university studies; with a total of 163 students registered at university in 2010.

The programme increased learners' self-confidence and self-esteem, improved their performance in mathematics and science and provided them with the opportunity of realizing their potential and setting goals for the future.

CONCLUSION

The programme allows the university to address:

- geographic and socio-economic marginalisation (access to tertiary education in the South African context)
- access to and success in university for first generation South African talented students from lower socio economic backgrounds and under performing schools; one which culminates in graduation with a first degree in Science, Engineering, Health Sciences, Maths and Science Education
- the needs of under performing schools by contributing to teacher development

This programme counters negative school or community influences (lack of rigorous curriculum, poorly trained teachers, lack of role models) by providing the missing elements that help students aspire to, prepare for, and obtain acceptance at University. The programme has encouraged learners to become involved in their communities and to work in groups and as a team as well as gaining exposure to computers and science equipment that are not readily available at their schools.

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THE CITIES COMENIUS PROJECT - CHEMISTRY AND INDUSTRY FOR TEACHERS IN EUROPEAN SCHOOLS

Raymond Wallace

School of Science & Technology Nottingham Trent University, UK

ray.wallace@ntu.ac.uk

Leo Gros

Hochschule Fresenius, Idstein, Germany

gros@hs-fresenius.de

ABSTRACT

THE CITIES COMENIUS PROJECT This project was an important Comenius project running from 2006-2009 and attracting over a quarter of a million Euros in funding from the European Commission. Its aim was to develop course modules which can be used by teachers in European schools to inform pupils in a positive and exciting way about what chemistry can achieve for them and society at large. One of its major outputs is a repository of resources available through its website at http://cities.eu.org/.

Keywords: *CITIES, Comenius, teaching materials, schools.*

INTRODUCTION

In many European countries, there is still an urgent need to interest more young people in studying chemistry. A Comenius funded European project, CITIES, Chemistry and Industry for Teachers in European Schools, which drew to a close at the end of 2009 set about developing teacher training modules which are designed to help teachers make their chemistry lessons more appealing to students by placing the subject in the context of their daily lives. Additionally through its website it has attempted to make students more engaged with chemistry by taking a diverse range of topics, many of which at first sight might appear to have nothing to do with chemistry, but which should attract their curiosity and presenting them in a lively manner. Thus information is to be found on, for example, fuel cells, liquid crystals, self-cleaning materials, condoms, packaging materials, food flavourings (Pringles), energy drinks, margarine, deodorants and antiperspirants alongside simple experiments which can be performed by students. Built around 4 modules, 'European context of chemical education, training and development', 'Commerce and innovation – our future', 'Chemistry changes everything', 'Chemistry – bringing it alive', the project also sought to inform teachers and pupils alike about the European context in which chemistry operates. Information therefore can also be discovered about European chemistry education, the European chemical industry, careers in chemistry and exciting or intriguing chemical science such as forensic investigations or the 'chemistry of a tin of ravioli' – all under one roof!

METHODS

The Comenius proposal was written and the partner consortium put together in Frankfurt in February 2006 and the project funded in the autumn of that year. The partners consisted of:
Contractor and Co-Coordinator: Europa Fachhochschule Fresenius (DE)
European Chemistry Employers' Group ECEG (BE)
European Mine, Chemical and Energy Workers' Federation EMCEF (BE)
Johann-Wolfgang-Goethe-Universität (DE)
Czech Chemical Society (CZ)
Gesellschaft Deutscher Chemiker (DE)
Institut Químic de Sarriá (ES)

Uniwersytet Jagielloński (PL)
Nottingham Trent University (UK)
Royal Society of Chemistry (UK)
Each partner has contributed in different ways to the project, some writing teaching materials, some trialing materials, others providing advice and support and so on.

RESULTS

CITIES products:

- Permanent website http://cities.eu.org, (accessible to both teachers and students & shortly to go fully live), with translated content in EN, PL, DE, CZ and ES, plus parts in TR, EE and PT
- CD-ROMs with learning/teaching material in EN, PL, DE, CZ, ES on request to CITIES national partner
- pdf versions of teaching/training material as downloadable files
- Handbook 'Chemical education in Europe' (EN, PL, CZ, DE, ES), with a multilingual glossary of key 'Euro-Chem' terms
- Help for teaching staff with training based on CITIES modules by national partners

Thus in the context of the modules described in the introduction, material can be found on the importance and scope of the chemical and related industries and what they do (Commerce and innovation – our future), a 'benefits landscape' of everyday uses of chemistry (Chemistry changes everything), experiments which relate to materials from everyday life (Chemistry – bringing it alive) and the employability of graduates in the global economy (European Context of chemical education, training & development). All this is designed to better inform teachers and their students about chemistry and help make it more relevant to their world.

Not only is there simple factual material but the consortium has also developed two in-service training courses for teachers, one in forensic science and one based around the chemistry of a tin of ravioli. The group has also produced a prototype 'Selling chemistry from a sample case' which is a model of a mobile experimental chemistry set with simple, safe experiments, plus Power Point presentations to relate everyday experience and chemistry.

CONCLUSIONS

Through this wealth of resources it is hoped that teachers and pupils alike with come to find chemistry a more meaningful and exciting experience.

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http://cities.eu.org

MACROSCOPIC PHENOMENA AND MICROSCOPIC PARTICLES: STUDENTS' DISCUSSION ABOUT RELATIONSHIPS BETWEEN CENTRAL CONCEPTS IN CELL BIOLOGY

Anna-Karin Westman

Mid Sweden University

anna-karin.westman@miun.se

ABSTRACT

This study analyses students' discussions about cell biology concepts. Research has shown students to have difficulties in relating macroscopic phenomena with microscopic particles and molecules. An assignment was created which included concepts from these organization levels. The aim of the study was to analyse the discussions, with focus on how students expressed their understanding for relationships between the concepts. The discussions included utterances often posed as questions. Analyses showed that students had a mainly correct understanding of the biological content. A conclusion in the study is that students designed their concept map by asking each other questions about the concepts.

Keywords: *understanding of concepts, cell biology, organization levels*

INTRODUCTION

Research has shown that students have difficulties in relating molecular and microscopic particles with macroscopic phenomena (Bahar, Johnstone, & Hansell, 1999). A part of the scientific knowledge is to be able to make connections between the tangible, macroscopic phenomena and abstract, microscopic concepts. In this study student groups discuss relationships between concepts from different organization levels during a task that involved constructing a concept map.

BACKGROUND

In this study cellular respiration was chosen as subject area. Research has shown this to be a subject area with difficulties for students (Songer & Mintzes, 1994).

CENTRAL AIM

This study aims to investigate how students discuss relationships between cell biology concepts from different organization levels.

The three research questions are:

How do the students express their understandings of relationships between concepts from different organization levels during the construction of a concept map?

To what extent do the students demonstrate an understanding of the biological content?

How do the students make agreements?

METHOD

A list of concepts was presented in the program CMapTools (Novak & Cañas, 2008). The task for the student groups was then to form a map that showed relationships between the concepts. Student groups' discussions were analysed in three ways. The analyses included what type of talk students used in these parts of the discussions (Mercer, 1995), how they demonstrated their understanding of the biological content (Mork, 2005) and also how they made agreements.

RESULTS

The results showed discussions were students used a way of expressing their views as questions and mostly biological correct content (Figure 1).

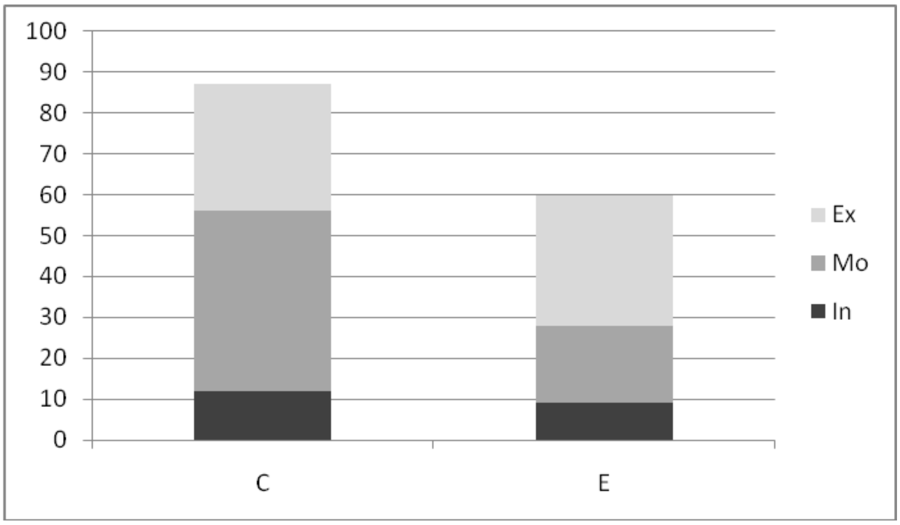

Figure 1 Categorisation of utterances. On the x-axis are the types of talk, C= Cumulative, E= Exploratory. The two categories are divided in to three levels of accuracy, In= incorrect, Mo= Moderate, Ex= expected (n=147).

The assignment made the students express their understandings of relationships between concepts from different organisation levels in cell biology. Agreements were made most often by a summation of the knowledge in the group. Questions replied by counter-questions were very common.

CONCLUSIONS

All individuals in the six groups had the common way of expressing their views as questions to the others. This can be interpreted as a sign of insecurity. On the other hand, analysis of the biological content in the discussions did not reveal any obvious misunderstandings of the included concepts. A minority of the utterances are incorrect. It is important to create learning situations that give students experience in “thinking at the cellular level” (Songer & Mintzes, 1994). In this study students discussed the concepts from different organization levels and their relationships with knowledge in many cases. An assessment of this kind may enhance understanding of a subject area.

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SELF-DETERMINATION, MOTIVATION AND CONCEPTUAL CHANGE IN PHYSICS LESSONS AT SECONDARY SCHOOLS

Angelika Wolf
University of Education
Heidelberg
Angelika.Wolf@ph-heidelberg.de

Matthias Laukenmann
University of Education
Heidelberg
Laukenmann@ph-heidelberg.de

ABSTRACT

The Self-Determination Theory of Motivation (SDT) presents one theoretical framework for Hentig's postulate (H. v. Hentig 2004) that learning requires independence individual responsibility and self-control of each learner.

This project tries to investigate the sustainability of this postulate. We are testing from three perspectives whether or not an observable connection between the degree of autonomy given and the students' subjective experience of social integration, autonomy and competence, exists. Therefore the study aims at investigating, whether the realization of those basic needs possibly lead to different levels of motivation and whether or not the degrees of self-determination, motivation and cognition are correlated.

Keywords: *Given Autonomy, Self-Determination, Motivation,*

Conceptual Change

INTRODUCTION

The study has two phases, sharing a common design.

The pilot study took place from March to June 2009. From October 2009 to April 2010, the main study takes place with 21 teachers and approximately 650 pupils of the eighth grade in the science lessons of secondary schools.

METHODS

The data collection investigates the degree of given autonomy, individual responsibility and self-determination offered to the learners. The data is collected from three perspectives (students, teachers and raters) with mainly standardised tests. Moreover, controlling variables, e.g. well-chosen areas of teacher's personality or students' beliefs are raised at the beginning. The factors experience of relatedness, of competence, of autonomy and motivational orientation are raised with the help of a standardised questionnaire at the beginning as well as at the end of the teaching unit. To measure the cognitive learning success (previous and specialized knowledge) two knowledge tests at the beginning and at the end of the series of lessons are conducted.

The evaluation of the data encompasses different analysis procedures. One the one way we make a quantitative analysis based on multivariate methods (covariance) analysis. Otherwise a path analysis and the development of multi-level effect model are intended.

RESULTS

The results of the pilot study showed mean correlations and high significances between the given autonomy (GA1/2) and the basic needs (Perceived Social Integration (PSI), the Perceived Support of Autonomy (PSA) and the Perceived Competence (PC) according to Deci and Ryan.

Furthermore the results demonstrated that there are mean correlations and high significances between the satisfaction of the basic needs and the different aspects of motivation, which confirm to the theory. That means for example, that a student, who doesn't perceive him-/herself as socially related, is with high probability amotivated and extrinsically motivated.

It is important to understand, that according to Deci and Ryan, all the three basic needs have to be satisfied in order for a student to have a high quality of motivation.

CONCLUSIONS

The main study will reexamine those trends and if possible verify them within a more representative population. The results will be presented.

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FACTOR ANALYSIS AND RASCH MODEL ANALYSIS OF THE ROSE STUDY ON CHINESE STUDENTS' INTEREST OF SCIENCE LEARNING

Yau-yuen YEUNG

Department of Science and Environmental Studies
The Hong Kong Institute of Education

E-mail：yyyeung@ied.edu.hk

May May-hung CHENG

Department of Education
The University of Oxford

E-mail: may.cheng@education.ox.ac.uk

ABSTRACT

A Chinese version of the international Relevance Of Science Education (ROSE) project was administered to a total of over 2,400 students in 70 classes of secondary schools in three Chinese cities, namely Hong Kong, Guangzhou and Shanghai. Apart from adopting the partial credit Rasch model for data analysis, exploratory factor analysis was applied to yield 24 key factors from this set of ROSE data. Finally, we shall make more in-depth discussion on a few selected topics in which there are either striking differences between students in Hong Kong and mainland China.

Keywords: *students' interest of science learning, Chinese learners, Rasch model*

INTRODUCTION

The study of student attitudes towards science or science learning has become a key component of science education in the past three to four decades. Apart from the validity and reliability of individual research instruments and methodologies, this vast body of attitudinal research (see, e.g. Gardner, 1975; Osborne, Simon, & Collins, 2003) has one major problem in common – the research instruments and methodologies have mainly been adopted by individual teams of researchers in specific contexts (and/or countries or regions). There is no easy way to undertake a comparative study directly from student responses as collected by different questionnaires or research instruments. Therefore, instead of developing a new instrument to collect Chinese student data on their interests, attitudes, views, and motivation in the affective domain of science education, we made a Chinese version of the international ROSE research instrument, of which the complete instrument and the proper procedures of administration have been fully documented in the research handbook by Schreiner & Sjøberg (2004). Our Chinese version includes a section for collecting its own set of socio-economic data and has undergone rigorous processes to ensure its validity and reliability.

RESEARCH METHODOLOGY AND FINDINGS

The partial credit Rasch model (see, e.g. Bond and Fox, 2007) was employed to carry out the quantitative analysis because it allows us to (a) find out the relative levels of endorseability for all of the items used in the questionnaire instrument and (b) make a more reliable comparison of student levels of agreeability (or interests/positive attitudes) with various sections of the questionnaire. The complete ROSE questionnaire contains 245 fixed response items in eight parts. As shown in Fig. 1, the Rasch analysis tells us that topics like "C10. Unsolved mysteries in outer space", and "C13. Why we dream while we are sleeping, and what the dreams may mean" are most interesting to those Chinese students while topics like "A17. Atoms and molecules", "A47. How petrol and diesel engines work", and "E1. Symmetries and patterns in leaves and flowers" are of least interest to them.

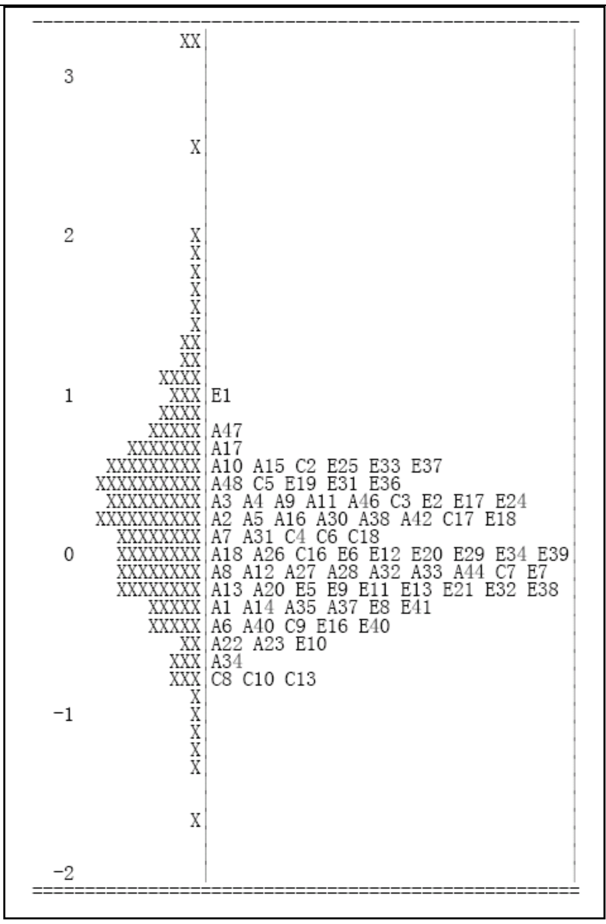

Figure 1: Map of latent distributions and response model parameter estimates as generated from the ConQuest software. The numbers in the left-most column are in logit scale which is a logarithmic transformation the odds of success (Bond and Fox, 2007). Each "X" in the distribution chart (LHS) represents 18.6 students who are having a certain level of interest in science learning. The labels on the RHS refer to the 81 science topics of the questions on "What I want to learn about – How interested are you in learning about the following?" in the ROSE instrument (Schreiner & Sjøberg, 2004). Their positions in the logit scale indicate the level of difficulty for the students to respond with interest in learning them, i.e. the lowest items like C8, C10 and C13 are most interesting to the students while the top items like E1, A47 and A17 are least interesting.

As we understand that the student affective domain of science learning is multidimensional in nature, we need to conduct an exploratory factor analysis to uncover various underlying constructs using the SPSS software. 24 key factors are yielded for this ROSE questionnaire and 11 of them are about what the students want to learn. Each factor (or category of science topics) contains 4 to 10 topics with the highest factor loading of 0.655 to 0.811. The overall alpha reliability for those 81 topics is 0.97. More detailed results on the quantitative comparison across the three cities between students' level of interest in various science topics vs gender, socioeconomic factors and banding of their schools will be presented in the full conference paper together with the qualitative results from the interview of students for providing plausible explanations on the similarity and differences on the students' interest of learning various science topics.

CONCLUSIONS

The ROSE instrument has been translated into Chinese for administration to around 2,400 students in 3 cities of China. Some quantitative analysis has been carried out using the

Rasch model of measurement and method of factor analysis, yielding a better understanding on the characteristics of the Chinese students on their views, interest and attitudes towards science learning.

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WIN, WIN, WIN, WIN, WIN! SCIENTIST, ENGINEERS, TEACHERS EDUCATIONS

Marjan Zadnik

Dept of Imaging and Applied Physics
Curtin University of Technology
GPO Box U 1987, Perth WA 6845
AUSTRALIA

m.zadnik@curtin.edu.au

David Blair

School of Physics
University of Western Australia
Crawley WA 6009
AUSTRALIA

dgb@cyllene.uwa.edu.au

David Coward

School of Physics
University of Western Australia
Crawley WA 6009
AUSTRALIA
coward@physics.uwa.edu.au

Nancy Longnecker

Faculty of Life and Physical Sciences
University of Western Australia
Crawley WA 6009
AUSTRALIA
nancy.longnecker@uwa.edu.au

Grady Venville

Graduate School of Education
University of Western Australia
Crawley WA 6009
AUSTRALIA

grady.venville@uwa.edu.au

ABSTRACT

International research has shown that fewer students are studying science and going onto science careers, with serious consequences for scientific understanding, literacy and national economies. Our research project links promoting and enhancing science education and communication, the “Gravity Discovery Centre” (GDC, a centre for school science enrichment), the “Graham (Polly) Farmer Foundation”, which provides education enrichment to indigenous disadvantaged students in remote schools, and a large new robotic Zadko telescope. This research will evaluate the effectiveness of science enrichment programs in changing school students’ attitudes towards science, career goals, and expectations as well as science understanding.

Keywords: *Science students’ enrolment, motivation, impact of science centres.*

INTRODUCTION

Students' Attitudes towards Science and Enrolment Decline: A Significant International Problem

This research focuses on understanding and improving high school students' attitudes towards science. Considerable evidence has accumulated to demonstrate that Australian and other countries' schools and universities are not producing enough scientists and engineers to sustain the scientific and economic development (DEST, 2006). Despite science and technology being key factors contributing to the economic growth and social prosperity in both advanced and developing nations, there is a worldwide phenomenon of declining student attitudes to science in developed nations (Sjoberg, 2005), including the UK (Office of Science and Technology and the Wellcome Trust, 2001), Europe (European Commission, 2007), the USA (National Academies Committee on Science, Engineering, and Public Policy, 2006) as well as Australia (DEST, 2006). Within Australia this phenomenon has been referred to as a crisis (Tytler, 2007) because it has resulted in "a decreasing proportion of students taking post-compulsory science; low levels of participation in tertiary courses in physics and chemistry and higher mathematics; [and] a shortage of graduates and research students in key areas" (Tytler & Symington, 2006, p. 40).

The problem of poor student attitudes towards science and falling enrolments in science subjects at the secondary and tertiary levels of education is of critical importance to the scientific and economic development of many countries. There are a number of indicators of the enormity of the problem. The most recent results from the Programme for International Student Assessment (PISA) conducted by the Organisation for Economic Cooperation and Development (OECD) showed that 15-year old Australian students showed very low interest in learning science. The Longitudinal Surveys of Australian Youth (Fullarton et al., 2003) show that between 1993 and 2001 national participation rates for Year 12 students in all science subject areas dropped (with the exception of psychology). In chemistry, for example, the participation rate dropped from 22.6% in 1993 to 17.8% in 2001. In addition to poor student attitudes towards science, falling achievement of Australian high school students in science is well documented and is making national headlines (Ferrari, 2008).

METHODS

This presentation will discuss different research methods evolving to evaluate three types of educational programs, all delivered through the Gravity Discovery Centre as follows:

Specialised Enrichment: Innovative high quality programs already developed and comparable to many enrichment programs offered by diverse facilities internationally. These activities include both pre-visit and post-visit classroom activities.
Motivating through Research: Students will use the Zadko telescope and interact with researchers. This aspect of the program will enable students to discover new astronomical objects and to provide improved data for known objects (asteroids, Near Earth Objects, gamma ray bursts and supernovae).
Learning through Narrative: Students will use the Cosmology Gallery facilities. Here we will focus on the story of the universe and compare cultural creation stories at the Gravity Discovery Centre with the scientific version. This unique facility is specifically designed for multi-cultural approaches to learning.

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THE SOCIAL OBJECTIVES OF EDUCATIION IN VIEWS OF JASPERS AND THE ROLE OF VIRTUAL EDUCATION

Saeid Zarghami Hamrah

Department of philosophy
Tarbiat Moallem University

E-mail: zarghamii2005@yahoo.com

Mohammadreza Behrangi

IOSTE regional representative of Persian gulf countries
Tarbiat Moallem University

E-mail: behrangi_m_r@yahoo.com

ABSTRACT

In this paper the objectives of education in views of Jaspers and the role of virtual education in them was studied. Jaspers believes that educating learners as useful members of community means, on one hand, preparing them for future life and job provided by virtual education and on the other hand, it means reviving and fostering traditions of that society to learners through day to day life, manner of speaking and social encountering like contact with human character of a teacher. Therefore, the virtual education can not be replaced face to face education. Finally some applied implications have been mentioned.

Keywords: *Virtual education, Information Technology, Social objectives of education, Jaspers*

INTRODUCTION

With attention to the importance of education and its role in the whole of human life and destiny, it is necessary alongside virtual education technical development, the role and its consequences on the whole education process and human life will be investigated.

Thoughts and questions about the technology date back to Greek, but by development of new technologies in the nineteenth century, and enveloping it in the twentieth century, philosophical questions of this technologies also has been spread and philosophers such as Heidegger(1977),for instance, less or more have evaluated technology and information technology and its consequences. Among the philosophers who have studied new Technologies the role of existence philosophers is more prominent and fundamental.

On the other hand, Jaspers (1956, 1957, 1963 and 1969), one of the main representatives of the philosophy of existence, have some ideas as educational philosopher. In the present study his ideas regarding the education and the relationship of virtual education with that are investigated. It seems that, on the one hand, education has a kind of communicational and social nature. On the other hand, Jaspers considers that "being self" and "becoming self" to be possible only on the basis of communication (1969). Therefore, social objectives of education can be investigated from the view points of Jaspers. Based on this fact, first some of the social objectives of education are deduced with regard to the Jaspers views and the role of virtual education in the achievement of these objectives are studied.

RESULTS

In the study the relationship between the virtual education and some of the social objectives of education were examined from the view of Jaspers.

Jaspers makes difference between "community" and "society" and believes that educating learners as useful members of community means, on the one hand, preparing them for future life, job and on the other hand, it means awakening, preserving and fostering the traditions and the genuine historical culture and soul of that community in students through day to day life, manner of speaking and social encountering like face to face contact with human character of teacher that Jaspers (Graic, 2000) calls "existential relation". He claims that "being self" and "becoming self" is possible only based on such communication; communication with others, traditions, culture and history. Jaspers in his emphasis on the role of communication in human evolution, even in the lowest level of life which is the ordinary life, refers to the deaf kids that were considered as dull before the creation of the sign language, but by the creation of the sign language as a communication device, the inaccuracy of the theory and the role and significance of communication were revealed (1963). Furthermore and Like Kierkegaard, (Prosser and Ward, 2000) it seems that we can introduce authentic person in relation to authentic community: authentic community knows its past and depends to it and so people have opportunity to conscious about the past of their community and connect to it.

Virtual education in connection with the first aspect, (preparing students for future life and job), has provided abundant opportunities: Nowadays, the easy and fast access to the information has, has moderated the extensive need for it and also has helped in saving the time for gathering information and so has accelerated the process of scientific production. As the consequence, the quality of the material life has increased. Every day the learners witness the achievements of Information Technology such as freeing human from illnesses and enriching his life with learning, art, sport, and recreation. As an example, we can mention the extensive virtual education that has facilitated the learning of such scientific skills as driving and piloting.

But alongside these achievements, virtual education also has changed the life pattern of teachers and students. For example, they rather communicate face to face, for their informational and even social needs, communicate virtually such as chat and email. Spreading the process is a challenge for the second aspect, i.e. awakening, preserving and fostering the traditions and the genuine historical soul of that community in students.

CONCLUSIONS

So the educational systems should train the teachers who are representative of traditions and authentic historical culture of that specific community. It should also provide the context for interactions between the teacher and learners in the school and community in order to animate the community's traditions and culture in the students and supply the ground for preserving and growing them.

on the foundation of research findings and by accepting the priority of the question concerning technological paradigm than question concerning how reforming by using it some applied implications as follow up virtual education beside face to face education and emphasis on holistic view than unilateral one in using virtual education have been mentioned in conclusion part of this paper..

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NATIONAL EXTENDED ABSTRACTS

POSSIBILITIES OF AUTHENTIC LEARNING OF CHEMISTRY (AND OTHER NATURAL SCIENCES) AT A HIGH SCHOOL
/
MOŽNOSTI AVTENTIČNEGA UČENJA KEMIJE (IN DRUGIH NARAVOSLOVNIH PREDMETOV) V GIMNAZIJI

Mojca Alif

I. gimnazija v Celju

Mojca.alif@guest.arnes.si

ABSTRACT

Research has shown that chemistry is not very well liked by high school students. We suppose the main reason for such a dislike of chemistry is the fact that students view it solely as relatively difficult theory. What they do not realise is its applicability in relation to life.

The best way to make students familiar with the practical side of chemistry is authentic learning. Therefore we introduced into chemistry lessons:

- research work
- project work
- excursions / field trips
- Natural Sciences Association

We have found that the intense application of various kinds of authentic learning within chemistry lessons raised students' interest in chemistry. Indicators: number of students choosing chemistry for the final examination (*matura*), students' success in competitions, number of research projects completed, choosing chemistry as a subject of further university study.

Keywords: *authentic learning, chemistry, research work, project work, excursions, scientific lectures*

UVOD

Raziskave izpred nekaj let (1, 2) so pokazale, da kemija med dijaki ni priljubljena. Eden glavnih vzrokov za to je dejstvo, da jo dijaki dojemajo le kot relativno zahtevno teorijo, ne vidijo pa njene uporabnosti in povezanosti z življenjem. Zato je najboljši način za povečanje priljubljenosti kemije, dijakom osmisliti kemijsko teorijo in jo povezati z življenjem.

METODA

Da bi povečali priljubljenost kemije med dijaki naše gimnazije in v njih vzbudili za naravoslovje nasploh, smo poskusili profesorji z različnimi novimi didaktičnimi in metodičnimi elementi spremeniti pouk kemije. Eden od teh elementov je avtentično učenje.

Na naši šoli smo uvedli naslednje oblike avtentičnega učenja:

- raziskovalno delo
- projektne dneve
- ekskurzije
- Naravoslovno društvo

Raziskovalno delo

Raziskovalne naloge s področja kemije opravljajo dijaki večinoma v povezavi z lokalno industrijo in laboratoriji. Za raziskovalne teme poskušamo izbrati čim bolj avtentične probleme. V eni od nalog smo v sodelovanju s tovarno Emo raziskali odpornost različnih vrst protikorozijske zaščite, v drugi z metodo obarjalne titracije določali količino natrijevega klorida (soli) v priljubljenih prigrizkih, v sodelovanju z Inštitutom za hmeljarstvo in pivovarstvo določali vsebnost telesu koristnih kovin v pivu, več raziskav pa smo opravili tudi v sodelovanju s Cinkarno.

Pri tem delu dijaki razvijajo raziskovalne kompetence in kar je morda še pomembneje, spoznajo praktično uporabo šolske teorije.

Projektni dnevi

Projektni dnevi omogočajo zelo učinkovito povezavo kemijske teorije s prakso. Primer projektnega dneva, ki smo ga izvedli letos: Analiza živil

Dijaki so, razdeljeni v pare ali trojice, analizirali živila. Določali so količino nitratov v zelenjavi, koncentracijo nitratov v vzorcih pitne vode, koncentracijo ocetne kisline v različnih vrstah kisa, koncentracijo sladkorja v sadnih sokovih in trdoto vode. Pri tem so se seznanili z različnimi eksperimentalnimi tehnikami (titracijo, ekstrakcijo, uporabo refraktometra, tehtanjem, uporabo indikatorskih lističev…), pa tudi s teorijo (škodljivost nitratov, trdota vode, nevtralizacijska titracija, kemijsko računanje…)

Ekskurzije

Uspešna in med dijaki zelo priljubljena oblika avtentičnega učenja so ekskurzije. Izvajamo jih tako v lokalnem okolju, kjer dijaki spoznavajo industrijske kemijske laboratorije, proizvodnjo v kemijskih tovarnah, ekološke službe tovarn (Cinkarna, Emo, Etol, Aero…) kot širše po Sloveniji (obisk Inštituta Jožef Stefan, inštitutov na Medicinski fakulteti, Kemijskega inštituta…) in Evropi (Tehnični muzej v Münchenu, Naravoslovni muzej na Dunaju, rudniki soli pri Salzburgu…).

Naravoslovno društvo

Najzanimivejša oblika avtentičnega učenja kemije na naši gimnaziji, morda celo edinstvena v Sloveniji, je Naravoslovno društvo. Ustanovljeno je bilo v začetku leta 2007 na pobudo peščice dijakov, ki jih je zanimalo naravoslovje. V okviru naravoslovnega društva vsak mesec organiziramo aktualna predavanja uglednih slovenskih znanstvenikov z različnih področij naravoslovja. V zadnjem času so se lahko dijaki seznanili z naslednjimi kemijskimi temami: nanodelci (uporaba, toksičnost), uporaba matematičnih metod pri razvozlavanju kemijskih struktur, kemijski mehanizmi odvisnosti, kemijske prilagoditve organizmov na življenje v ekstremnih okoljih, biokemija gripe (o virusih in cepivih proti gripi)…Na teh predavanjih dijaki spoznajo različna področja znanosti, kjer je mogoče uporabiti znanje kemije, spoznajo najaktualnejša naravoslovna znanstvena vprašanja in tesno medsebojno povezanost različnih naravoslovnih področij.

Poleg predavanj, ki jih mesečno organiziramo na šoli, pa društvo skrbi za popularizacijo naravoslovja tudi s tem, da dijakom predstavljamo različne študije in poklice v naravoslovju.

REZULTATI

Na šoli ugotavljamo, da se je s spremenjenim načinom poučevanja kemije spremenil tudi odnos

dijakov do tega predmeta. Kot dokaz za to štejemo:

- povečanje števila dijakov, ki opravljajo maturo iz kemije
- povečanje števila in kvalitete dosežkov naših dijakov na državnem tekmovanju iz kemije, pogosto uvrstitev na mednarodno kemijsko olimpijado in evropsko olimpijado iz naravoslovja
- povečanje števila dijakov, ki se odločijo za študij kemije, biokemije, farmacije
- in nenazadnje: z avtentičnim učenjem vzbudimo zanimanje za kemijo tudi pri tistih dijakih, ki jih teorija kemije ne zanima.

ZAKLJUČEK

Rezultati analiz kažejo, da kemija med dijaki ni priljubljena. Eden od vzrokov za to je dejstvo, da dijaki zaznavajo kemijo le kot relativno zahtevno teorijo, ne poznajo pa raznotere možne uporabe te teorije v industriji, medicini in drugih področjih človekove dejavnosti. Prav zato smo prišli na idejo, da bi bilo mogoče priljubljenost kemije povečati s tem, da dijakom čim nazorneje predstavimo povezanost šolske kemijske teorije s prakso.

Z različnimi oblikami avtentičnega učenja (raziskovalno delo, projektni dnevi, tematske ekskurzije in aktivnosti Naravoslovnega društva) nam je to uspelo. Posebej zanimiva in edinstvena oblika avtentičnega učenja, ki jo (vsaj kot je nam znano) izvajamo samo na naši gimnaziji, so predavanja priznanih znanstvenikov, ki dijake seznanjajo z aktualnimi naravoslovnimi temami.

Da je kemija postala med dijaki bolj priljubljena, dokazuje povečanje števila dijakov, ki izberejo kemijo za maturo, večja uspešnost naših dijakov na državnem tekmovanju iz kemije in redno uvrščanje v ekipo za mednarodno kemijsko olimpijado ter znatno povečanje števila dijakov, ki se odločijo za študij kemije, biokemije, farmacije in drugih ved, povezanih s kemijo.

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CHEMISTRY ACHIEVEMENTS OF SLOVENIAN STUDENTS IN INTERNATIONAL STUDIES / KEMIJSKI DOSEŽKI SLOVENSKIH UČENCEV V MEDNARODNIH RAZISKAVAH

Andreja Bačnik
Zavod RS za šolstvo
andreja.bacnik@zrss.si

Mariza Skvarč
Zavod RS za šolstvo
mariza.skvarc@zrss.si

ABSTRACT

Slovenia participated in major international studies in science education, namely TIMSS – Trends in International mathematics and Science Study and PISA – Programme for International Student Assessment. The last data collections on student science achievement conducted in Slovenia were PISA 2006 and TIMSS 2007. This paper presents science, chemistry achievement of Slovene students in comparison with other countries in both mentioned international studies. Slovene chemistry achievements on international level are relatively high and regularly higher than achievements in other science subjects.

Keywords: *international studies, PISA, TIMSS, science, chemistry achievement*

UVOD

V analizi kemijskih dosežkih slovenskih učencev v mednarodnem merilu upoštevamo dve odmevni mednarodni raziskavi na področju naravoslovja: TIMSS (Trends in International Mathematics and Science Study) in PISA (Programme for International Student Assesment). Zadnji mednarodni podatki o kemijskih dosežkih s katerimi razpolagamo so iz raziskave TIMSS 2007 in iz merjenja naravoslovne pismenosti PISA 2006. V prispevku želimo analizirati dosežke slovenskih učencev na področju kemije, v primerjavi z mednarodnimi dosežki iz obeh omenjenih raziskav.

METODA

Analiza kemijskih dosežkov slovenskih učencev v mednarodnih raziskavah TIMSS 2007 in PISA 2006 je temeljila na poglobljeni sekundarni analizi dosežkov slovenskih učencev v primerjavi z mednarodnimi dosežki učencev, objavljenimi v mednarodnih in nacionalnih poročilih.

REZULTATI

Ko analiziramo dosežke iz naravoslovnih predmetov slovenskih učencev v raziskavi **TIMSS 2007**, ugotavljamo, da so relativno visoki, saj so statistično pomembno višji od povprečja mednarodne lestvice (500 točk). Če pogledamo dosežke na skupini nalog, ki iz mednarodne opredelitve pokrivajo področje kemije je razvidno, da slovenski učenci na kemijskih nalogah izkazujejo zelo visoke dosežke. Iz poročila o raziskavi TIMSS 2007 ugotovimo, da dosežki slovenskih učencev na področju biologije (8. mesto od 49) in fizike (9. mesto od 49) zaostajajo za kemijskimi (4. mesto od 49), a so vsi nadpovprečni. Prav tako lahko iz podatkov (rezultatov) raziskave zaključimo, da so dosežki in napredki naših učencev v naravoslovju večji kot v matematiki. Ker so v raziskavi TIMSS naloge razdeljene po vsebinskih področjih naravoslovja: kemija, biologija, fizika in geografija, je analiza in primerjava dosežkov po predmetnih področjih lažja kot v raziskavi PISA, vendar ob natančnejši analizi objavljenih nalog raziskave TIMSS 2007 in njihovi razvrstitvi na posamezna naravoslovna področja ugotavljamo, da je kar nekaj vsebin opredeljenih v raziskavi kot fizikalnih zastopanih tudi v kemijskem kurikulu in obratno, na kar velja biti pozoren pri sami analizi nalog. Število kemijskih nalog v raziskavi TIMSS 2007 je bilo 41. Pri primerjavi načrtovanih odstotkov časa v preizkusih za posamezna vsebinska naravoslovna področja za osmošolce ugotavljamo, da je največji delež namenjen biologiji (35 %), potem sledi fizika (25%) ter kemija in vede o Zemlji (s po 20%). Za lažjo orientacijo med nalogami so le te v raziskavi dodatno razdeljene v tri kognitivna področja: znanje (poznavanje dejstev, postopkov in pojmov), uporaba (uporaba znanja in razumevanja konceptov) in sklepanja (sklepaje in utemeljevanje). V analizi kemijskih nalog po teh treh področjih, lahko ugotovimo, da je na področju kemijskega znanja Slovenija z nalogama, kjer učenec prepozna da je kisik plin potreben za izgorevanje in kjer mora učenec prepoznati formulo za ogljikov dioksid (93,6 % pravilnih odgovorov) uvrščena na šesto in sedmo mesto med vsemi sodelujočimi državami, na petnajstem mestu po odstotkih pravilnih odgovorov pa je naloga prepoznavanja snovi, ki dobro prevaja toploto in elektriko. Slovenski učenci dobro prepoznajo vinski kis kot kislino (75,3 % pravilnih odgovorov), iz opisa spoznavajo spremembo barve indikatorja pri nevtralizaciji (66,3 % pravilnih odgovorov). Pri zapisu dveh spremembi, ki jih lahko opazimo med kemijsko reakcijo, jih je 40% znalo zapisati le eno in 31,1 % (pravilno) dve spremembi. Na področju kemije in uporabe Slovenija v primerjavi z ostalimi sodelujočimi državami uvrščena visoko. Slovenski učenci dobro obvladajo pogoje za rjavenje. Da sta za rjavenje potrebna voda in kisik iz zraka je pravilno odgovorilo 84,2 % učencev. Prav tako slovenski učenci dobro prepoznavajo katera raztopina je bolj razredčena in pojasnijo svojo odločitev (76,3% pravilnih odgovorov, pri čemer je zanimiva in vprašljiva razlika med deležem pravilnih odgovorov pri dekletih (82,1 %) in fantih (70,4 %)). Pri nalogi, ki preverja kaj povzroči, da se balon napihne, ko se soda bikarbona in kis pomešata je delež vseh pravilnih dogovor 42,9 % in je med dekleti (36,0 %) in fanti (49,9%) obratna slika. Pri tej nalogi je pomembno še to, da jih je od omenjenih 42,9% učencev s pravilnim odgovorom, le slabih 10% vedelo, da pri reakciji nastane ogljikov dioksid, 17,2 % da nastane plin in 15,8 % da poteče kemijska reakcija, kar je relativno primerljivo z mednarodnim povprečjem. Razlaga, da je kemijska sprememba v mleku povzročila spremembo lakmusovega papirja je vedela večina naših učencev, a le 37,1 % jih je to znala pojasniti (pravilni odgovor). Zakaj kocka ledu ostane zmrznjena dlje časa v lesenem, kot kovinskem zaboju je pravilno sklepalo le 17,6% učencev. Na področju kemije in sklepanja so slovenski učenci v primerjavi z ostalimi pokazali slabše znanje pri nalogah o gostoti snovi, prostornini verižice (le 19,1 % pravilnih odgovorov) in s tem določanje prostornine nepravilnim telesom. Branje tabel slovenskim učencem ne povzroča večjih težav (72,0 % pravilnih odgovorov). Nekoliko več težav je pri interpretaciji podatkov iz tabel. Le 23,2, % slovenskih učencev je za primere ločevanje zmesi znalo pojasniti »korake« oz. razloge ločevanja.

Pri raziskavi **PISA 2006**, ki je konceptualno precej različna od raziskave TIMSS, je sestava pisnih preizkusov glede na vsebino (kategorije znanja) razdeljena na naravoslovno znanje (fizikalni sistemi, živi sistemi, sistemi Zemlje in vesolje,tehnološki sistemi), kar je pokrilo cca. 60 % nalog in na znanje o naravoslovni znanosti (znanstveno raziskovanje, znanstvene razlage) zajeto v cca. 40% nalog. Kemijske vsebine so bile v raziskavi PISA vključene v fizikalne sisteme in obsegajo zgradbo snovi, lastnosti snovi, kemijske spremembe snovi, energijo in njene pretvorbe ter kemijsko reakcijo. Med objavljenimi nalogami raziskave PISA 2006 na kemijsko področje segajo naslednje naloge: Zaščita pred soncem, Oblačila, Kisli dež in Učinek tople grede. Če primerjamo dosežkov slovenskih učencev na nalogah iz sklopa fizikalni sistemi z drugimi državami ugotovimo, da so dosežki slovenskih učencev relativno visoki. Pri primerjavi dosežkov slovenskih učencev med sklopoma Fizikalni sistemi in Živi sistemi, ugotovimo, da smo se bolje odrezali pri Fizikalnih sistemi, kamor spadajo tudi kemijske vsebine. Pri tem pa je treba opozoriti, da število nalog v posameznih področjih ni enakomerno in je sklop Živi sistemi veliko bolj zastopan z nalogami v preizkusu znanja kot sklop Fizikalni sistemi. Posplošljivost rezultatov na manjših sklopih nalog je sicer šibkejša kot na večjih sklopih, kljub temu pa iz rezultatov lahko izluščimo zgornjo ugotovitev. Primerjava lestvice skupnih naravoslovnih dosežkov z lestvico dosežkov na področju fizikalni sistemi pokaže napredek Slovenije, ob tem pa imajo največji napredek še Madžarska, Češka in Slovaška, kar morda nakazuje poudarke v njihovem (in našem) poučevanju naravoslovja. Na lestvici dosežkov iz znanja o naravoslovnih znanosti PISA 2006 so dosežki slovenskih učencev relativno nižji kot v primeru sklopa Fizikalni sistemi ali če rečemo drugače: v mednarodnem merilu so slovenski učenci uspešnejši v znanjih iz Fizikalnih sistemov kot v znanjih o naravoslovnih znanostih. Eden od možnih vzrokov za to je lahko večja povezanost vsebin nalog Fizikalnih sistemov s kurikulom. Zanimivo je tudi to, da podoben kontrast med temi dosežki lahko opazimo tudi za Češko, Madžarsko in Slovaško in ga lahko dobro ilustriramo z analizo posameznih vprašanj »kemijskih« nalog, npr. Kisli dež (2. vpr. (znanje naravoslovja): Slovenija - 57,6 % pravilnih odgovorov (povprečje OECD: 57,7 %) in 5. vpr. (znanje o naravoslovnih znanostih): Slovenija - 15,6 % pravilnih odgovorov (delno pravilnih odgovorov 42,4 %) povprečje OECD - 35,6 %.

ZAKLJUČEK

Zadnji mednarodni podatki o kemijskih dosežkih slovenskih učencev s katerimi razpolagamo so iz raziskave TIMSS 2007 in iz merjenja naravoslovne pismenosti PISA 2006. Raziskavi se po konceptualni zasnovi znanja kemijskega področja (in pri drugih metodoloških elementih merjenja znanja) med seboj precej razlikujeta, kar pa lahko izkoristimo za širšo in bolj poglobljeno sliko o znanju slovenskih učencev. Splošna ugotovitev, ki jo prepoznamo v obeh raziskavah, je, da so kemijski dosežki slovenskih učencev v mednarodnem merilu visoki in hkrati praviloma višji od dosežkov na drugih naravoslovnih področjih. Pri tem pa ni povsem nepomembno dejstvo, da so kemijske vsebine v obeh raziskavah (posebej PISA) zastopano z relativno majhnim deležem nalog. Prav tako mednarodna klasifikacija, razvrstitev v vsebinska področja, ne sovpada povsem z slovenskim kurikulom kemije. Ugotavljamo, da ne moremo določiti dosežkov pri posameznih nalogah kot dobre ali slabe znotraj posameznega področja klasifikacij posamezne raziskave, temveč se je potrebno posvetiti nalogam samim in pogledati katere so tiste naloge oz. znanja, kjer slovenske učenke in učenci dosegajo visoke dosežke oz. obratno. In nekaj takih je predstavljenih v tem prispevku.

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READING LITERACY, PHYSICS, AND NATIONAL ASSESSMENT OF KNOWLEDGE
/
BRALNA PISMENOST, FIZIKA IN NACIONALNO PREVERJANJE ZNANJA

Jurij Bajc

Univerza v Ljubljani, Pedagoška fakulteta

jurij.bajc@pef.uni-lj.si

ABSTRACT

Reading literacy among youth in Slovenia is an endangered species. These problems do not seem to be present in physics or other natural sciences, but this is unfortunately so mostly because the teacher's are adapting to decreasing literacy. In the paper a few examples from school practice and national assessment tests are used to demonstrate the necessity of the continuous development of reading competence at all school levels, because it is one of the key competences and it is crucial for lifelong learning.

Everyday problems cannot be divided into mathematical, linguistic, nature or social scientific, as there is a bit of all these ingredients in each of them. It is therefore crucial to prepare the pupils for real complex problems and not to feed them with oversimplified "school examples" alone. At physics class the teachers do not dare to post realistic problems with substantial text, as we are suppose to assess or grade the knowledge of physics and not of mother tongue. The pupils learn to strictly distinguish the subjects among themselves and the teachers follow with even simpler wordings and oversimplified examples, such as "The force *F* acts on a body." In this from bad to worse circle, not only are the pupils less interested in natural sciences or mathematics or physics, but their reading literacy is getting worse as well. Therefore, the only way out is to demand more from those who are capable to learn, to interconnect subjects, and to find new ways of showing the power of global knowledge. Those who learn harder need to be encouraged, but no further lowering of minimal demanded knowledge is acceptable, because this does not do the pupils any good in long term.

Keywords: *Reading literacy, physics, knowledge assessment*

UVOD

V Sloveniji in v svetu je v zadnjih letih opaziti zmanjševanje znanja po končanem pred univerzitetnem izobraževanju, kar je sledi tudi iz trendov mednarodnih raziskav, na primer PISA ali TIMSS. Šolske reforme pri nas so po drugi strani vse bolj naravnane v učencem prijazno šolo. Z rezultati oziroma posledicami teh sprememb v šolskem sistemu in v odnosu do znanja na sploh ne moremo biti zadovoljni. Namesto, da bi se zaradi prijetnejšega vzdušja učenci lažje in bolje učili, je opaziti porast težav, ki jih je bilo prej malo. Otroci tudi v višjih razredih osnovne šole čedalje slabše obvladajo tako osnovne matematične operacije –

na primer, odštevanje ali deljenje – kot osnovna slovnična pravila – denimo, uporaba velike začetnice ali postavljanje vejic. Posledica obojega je, da težko sledijo pouku pri naravoslovnih predmetih, posebej fiziki. Bralna pismenost je poseben problem, ker se tako učenci kot starši hitro odločijo, da pri pouku matematike, fizike ali kemije obsežnejša besedila nimajo mesta, ker da ti predmeti niso slovenščina. Tako si pri fiziki ne upamo postavljati realnih problemov z veliko besedila, saj preverjamo ali ocenjujemo znanje fizike in ne znanje jezika.

Primeri v prispevku naj ilustrirajo resnost stanja in naj nas spodbudijo k prenehanju prilagajanja ne-delu učencev.

PRIMERI

Prvi primer – definicija sestavljene količine

V osnovni šoli se pri fiziki srečamo že v osmem razredu z dvema sestavljenima količinama, ki ju učitelji označujejo kot zahtevni. To sta gostota in tlak. Posredno se z obema količinama otroci srečajo že v nižjih razredih devetletne osnovne šole, pri naravoslovju v 6. in 7. ter pri naravoslovju in tehniki v 4. in 5. razredu.

Ob vpeljavi gostote je učitelj zapisal enačbo $\rho = m/V$ in ob tem otrokom narekoval: "Gostota je sorazmerna z maso in obratno sorazmerna s prostornino.". Ob enačbi bi lahko, denimo, dejal tudi kaj takega: "Gostota nam pove, kolikšno maso ima enota prostornine neke snovi." Kaj od tega je bolj prav? Otroci so vsaj v osnovni šoli velikokrat zgolj prepisovalci, ki se o vsebini med poukom ne sprašujejo kaj dosti, doma pa se učijo raje po zapiskih kot po učbenikih. In zato ne opazijo razlike med obema izjavama. Videč le enačbo ta tudi obe videti ne napačni. Pa vendarle je pomembna razlika. Če ob vpeljavi povemo več, če učence, na primer, opozorimo na to, da je gostota lastnost neke snovi, na primer sladkorja ali železa, potem bodo hitro videli, da je druga izjava vsebinsko bolj ustrezna kot prva, saj je v izjavi sami implicitno vsebovano to, da je gostota lastnost snovi in ne, recimo, posameznega predmeta iz te snovi. Nasprotno pa prva izjava učenca navaja na misel, da bo gostota večja, če bomo povečali maso telesa, da se torej razlikuje od telesa do telesa iz iste snovi in ne opisuje snovi kot take.

S tlakom je podobno. Definicijska enačba se glasi $p = F/S$, kar lahko podobno kot prej interpretiramo ali kot "Tlak je sorazmeren sili in obratno sorazmeren ploščini ploskve." ali pa kot "Tlak nam pove, kolikšna sila deluje na enoto površine neke ploskve.". V tem primeru med izjavama ni velike vsebinske razlike, ker tlak za razliko od gostote ne opisuje lastnosti snovi, ampak je tako imenovana zunanja (eksterna) količina. Sile na telo se spreminjajo in v tem smislu ima prva izjava, da je tlak sorazmeren s silo, oprijemljiv fizikalni pomen. Če bomo na neko ploskev delovali z večjo silo, bo tlak tam večji. Podobno bo tlak pod ozko visoko peto damskega čevlja večji kot pod udobnim športnim copatom, ker je ploščina podplata na visoki peti mnogo manjša od ploščine pete športnega copata, teža pa v vsakem primeru približno enaka. Tudi druga izjava je smiselna, saj besedilno definira količino tlak kot kvocient med silo in ploskvijo.

Ob primernih zgledih iz vsakdanjega življenja bi morali otrokom že v nižjih razredih približati zveze med količinami, ki jih v višjih razredih spoznavajo v obliki enačb, po drugi strani pa bi še bolj nujno morali pri naravoslovnih predmetih, kot sta predvsem fizika in kemija, učenci enačbe ponotranjiti tudi v besedilni obliki. Za doseganje funkcionalne pismenosti bi morali in je po mojem mnenju tudi mogoče že v osnovni šoli doseči, da bi učenci abstrahirali do te mere, da bi znali povedano relacijo pretopiti v matematično relacijo oziroma enačbo in zapisano enačbo pomensko prebrati kot smiselno poved. To nikakor ni domena materinega jezika ampak nujni element naravoslovnih predmetov.

Drugi primer – besedilni fizikalni nalogi iz nacionalnih preverjanj znanja

Ob sestavljanju nalog iz fizike za nacionalno preverjanje znanja se ves čas srečujemo s problemom, koliko sme besedilo naloge biti opis realnega problema iz vsakdanjega življenja in koliko mora biti besedilo oblikovano kot "šolski primer" naloge. To drugo nam seveda bolje definira težavnost in preverjane cilje, omogoča bolj objektivno vrednotenje in s tem uporabnost nacionalnega preverjanja kot merilnega instrumenta. Po drugi strani so naloge v preizkusih dostikrat zgled učiteljem za oblikovanje nalog pri rednem delu z učenci. V duhu krepitve bralne pismenosti bi bilo potem smiselno nalogo oblikovati bolj "življenjsko" tudi za ceno malo daljšega besedila.

Prvi primer je po mnenju komisije relativno preprosta naloga, za katero je komisija tudi dobro vnaprej napovedala težavnost, saj je napovedi 0,50 (50 % učencev naj bi nalogo rešilo) sledila izmerjena težavnost 0,54 (Slika 1).

Naloga 11

V električni krog z generatorjem sta zaporedno vezani enaki žarnici. Skozi prvo se pretoči naboj 150 As. Kolikšen naboj se pretoči skozi generator v enakem času?

Obkroži črko pred pravilnim odgovorom.

A Skozi generator se ne pretoči nič naboja.

B Skozi generator se pretoči 150 As.

C Skozi generator se pretoči 300 As.

D Skozi generator se pretoči 450 As.

Slika 1: Primer naloge iz preizkusa rednega roka v šolskem letu 2006/2007.

Kljub temu, da je komisija dobro napovedala, da bo nalogo rešila okoli polovica učencev, ni povsem jasno, zakaj pravilnih rešitev ni več. Ker predmetna komisija za fiziko pri vrednotenju od učiteljev zahteva, da beležijo pri vprašanjih izbirnega tipa tudi nepravilne odgovore, lahko to vsaj špekulativno pojasnimo. Videti je, da sta razlagi dve, ali veliko učencev res ne razume oziroma ne prepozna zakona o ohranitvi električnega naboja, ali pa veliko učencev meša vzporedno in vzporedno vezavo. V tem primeru je ključna besedica v besedilu naloge "zaporedno", ker opisuje vrsto vezave dveh upornikov in generatorja. Besedilo je v ostalem delu jasno in lahko razumljivo.

Tabela 1: Število posameznih izbranih odgovorov pri primeru iz preizkusa rednega roka v šolskem letu 2006/2007. Izbira '0' pomeni, da učenec ni izbral nobenega odgovora.

Odgovor	A	B	C	D	0
Št. učencev	332	2458	1601	61	91

Na podlagi frekvence posameznih odgovorov (Tabela 1) je precej bolj verjetno, da so učenci zamenjali ali slabo prebrali besedilo in namesto za zaporedno razmišljali o rešitvi za vzporedno vezavo, saj so tak odgovor (B) izbrali 1,5 krat bolj pogosto kot pravilni odgovor (C), poleg tega je pogostost ostalih dveh napačnih odgovorov (A, D) ali izbira nobenega od odgovorov (0) zelo majhna, skupaj manj kot 11 %. Samo na podlagi analize odgovorov ne vemo, koliko izmerjeni rezultat odseva nepoznavanje fizikalne razlike med zaporedno in vzporedno vezavo, koliko pa je bilo napak zaradi površnega branja. V vsakem primeru je tako eno kot drugo direktno povezano z razumevanjem besedila, saj je tudi fizikalno razlikovanje med "*vzporedno*" in "*zaporedno*" vezavo pravzaprav le razumevanje obeh besed. Nalogo je uspešno, kar pomeni več kot v okoli 2/3 primerov, rešilo le 10 % najbolj uspešnih učencev. Za približno toliko učencev bi torej lahko rekli, da nimajo težav z razumevanjem pisanega besedila.

Drugi primer je naloga iz preizkusa v šolskem letu 2007/2008 (slika 2). Nalogo so učenci reševali po pričakovanjih, v celotni populaciji jo je rešilo 44 % učencev, komisija pa je pričakovala uspešnost okoli 40 %. Učitelji so komisiji v povratni informaciji na srečanju v Koloseju 2. oktobra 2008 in ob drugih srečanjih sporočili, da je imela naloga preveč besedila in da je to eden od razlogov za manjšo uspešnost. Tudi v tem primeru je nalogo uspešno rešilo le 10 % najbolj uspešnih učencev.

Naloga 7

Po zelo dolgem ravnem asfaltiranem klancu začne drseti velik kos snega z maso 100 kg. Med gibanjem je hitrost sneženega kosa stalna. Zaradi trenja se ves čas od kosa kruši po malo snega, del snega pod kosom pa se med drsenjem tudi tali, tako da je masa sneženega kosa ob vznožju za 5 kg manjša.

Katera od spodnjih izjav pravilno opisuje dogajanje med enakomernim drsenjem sneženega kosa?

Obkroži črko pred pravilnim odgovorom.

A Kinetična energija kosa se veča, ker se notranja energija kosa

Slika 2: Primer naloge iz preizkusa rednega roka v šolskem letu 2007/2008.

ZAKLJUČEK

V želji po boljšem sprejetju fizike ali drugih naravoslovnih predmetov se učitelji vse bolj prilagajamo slabšemu znanju učencev. Slabše znanje verjetno ni znak vse manjše sposobnosti učencev, temveč prej njihove vse manjše odgovornosti in pripravljenosti za resno šolsko delo. Učitelji pripravljamo poenostavljene naloge in primere, ki so suhoparni in jih učenci ne znajo povezati z vsakodnevnimi izkušnjami, zato fizike ne marajo, je ne razumejo in ne prepoznajo koristnosti naravoslovja. Namesto, da bi primere približali realnim situacijam in jih naredili zanimive, učitelji ponujamo še elementarnejše zglede, ki naj bi jih nezainteresirani poslušalci le nekako razumeli. Pri tem upamo, da bodo sčasoma spoznali, da je naravoslovno znanje še kako koristno. Učenci nikakor niso neumni in v zadnjih letih so se predvsem dobro naučili, da manj ko se trudijo, bolj smo tolerantni in manj zahtevamo. Na žalost učencev ne moremo ničesar naučiti učitelji, če se sami ne potrudijo in ne naučijo sami sebe. Zato je nujno pri pouku malo zmanjšati prijaznost in malo zvišati zahtevnost, če le iskreno želimo koristiti otrokom.

Z nekaj primeri smo nakazali, kako zaskrbljujoče je obstoječe stanje in kako nujno je od učencev v višjih razredih osnovne šole ali v gimnaziji pričakovati, da tisto, kar naj bi se naučili v predhodnem šolanju, tudi zares znajo. Bralno pismenost je nujno razvijati pri vseh predmetih, saj je ta kompetenca nujna za uspešnost tako pri šolanju, kot pri vseživljenjskem učenju in pri uspešnosti spopadanja z vsakodnevnimi problemi odraslega življenja.

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CLASSIFYING FRUITS AND UNDERSTANDING NATURAL DIVERSITY
/
PREPOZNAVANJE PLODOV PRI ZAČETNEM NARAVOSLOVJU

Barbara Bajd

Univerza v Ljubljani, Pedagoška fakulteta

barbara.bajd@guest.arnes.si

ABSTRACT

For effective science teaching it is necessary to provide children with opportunities in which they can engage with nature using all their senses, so that they directly experience as many aspects of natural diversity as possible. Such real, direct experiences of the natural world are, for children, the best teacher of all.

For example, through encouraging children to differentiate, describe and classify fruits, we promote and develop several of their crucial processing skills: observing with different senses, sorting, ordering, classifying, counting, measuring, weighting and comparing. Classifying fruits is an activity that can be performed with children of different ages and abilities using familiar, easily available materials. Observing, sorting, ordering and classifying are also the first steps to understanding natural diversity and introduce children in an easy and familiar way to reading biological keys.

UVOD

Otroci že v vrtcu spoznavajo naravo, živali in rastline ter njihove dele, kot so list, korenina cvet in plod. V vsakdanjem življenju velikokrat uporabljamo besedo plod, ki pa ni mišljena kot botanična opredelitev ploda. Včasih govorimo o plodu celoletnega truda, o plodu domišljije in pri tem ne mislimo na rastlinski plod. Velikokrat namesto besede plod uporabljamo besedo sadež ali sadje, kar lahko vodi do napačnega razumevanja botanične definicije ploda.

Pri začetnem naravoslovju otroke usmerjamo v opazovanje in spoznavanje plodov in pri tem razvijamo naravoslovne postopke. Eden prvih postopkov je natančno opazovanje, primerjanje, razvrščanje, urejanje, uvrščanje, merjenje in tehtanje (Harlow, 1992, Ferbar, 1996). Poleg tega otroke seznanimo, kako so zgrajeni preprosti biološki ključi za določanje organizmov (Bajd, 2001, Bajd 2002). Pri opazovanju otroci uporabljajo različna čutila. Zato je spoznavanje plodov, ki so užitni, za otroke zelo zanimivo, saj lahko uporabijo več čutil (tudi okus) in si tako značilnosti posameznih plodov tudi bolje zapomnijo. Pri prepoznavanju in razvrščanju plodov pa se otroci učijo različnih spremenljivk, ki jim kasneje pomagajo pri branju preprostih bioloških ključev za določanje organizmov.

Razvrščanje plodov je ena od aktivnosti, ki jo lahko izvajajo otroci različnih starosti in sposobnosti. Pri tem uporabljajo različna čutila, ne samo vid ampak tudi vonj, okus in tip.

Celo odrasli imajo včasih težave pri prepoznavanju plodov, zlasti če jim ponudimo zbirko, v kateri je veliko različnih predstavnikov sadja in zelenjave. Problem se pojavi, ker nimamo natančne definicije sadja in zelenjave. Angleži sadje imenujejo »fruit« in pomeni isto kot plod. Še večja zmeda pa nastane, ko govorimo o sadežih (na primer gozdni sadeži, kamor prištevamo gobe, borovnice, jagode). Gobe niso ne sadež, ne plod in jih uvrščamo v posebno kraljestvo gliv. Plodove imajo rastline iz skupine semenk, ko po oploditvi iz cveta nastane plod in v njem seme. Iz semena pa zraste v ugodnih razmerah nova rastlina. Goba nima ne cveta ne ploda. Kako lahko otroke seznanimo, kaj je plod? Kaj je definicija sadja in kaj zelenjave?

METODA

Otrokom ponudimo zbirko različnih plodov, ki se razlikujejo po velikosti, barvi, obliki. Nekateri so na otip kosmati (breskev, kokosov oreh, kivi). Tako lahko zbirka vsebuje jabolka (različnih barv, velikosti in oblik), pomarančo, banano, slivo, breskev, limono, kivi, kumaro, paradižnik, jajčevec, papriko, bučko. Če delamo s starejšimi otroki lahko poleg plodov damo v zbirko tudi korenje, cvetačo, krompir, čebulo, torej rastlinske dele, ki jih uporabljamo v prehrani, vendar niso plodovi.

Tako otroke najprej prosimo, da razvrstijo plodove po lastnem kriteriju. Najprej morajo otroci vedeti, kaj je plod, in tiste rastline, ki niso plod izločiti iz zbirke. Marsikdo ne posluša natančno navodil in začne tako z razvrščanjem. Tu nastane kar nekaj težav, toda po pogovoru in natančnem ogledu spoznajo, da plod vsebuje seme in da tisti deli rastlin, ki nimajo semen, niso pravi plodovi. Pogovorimo se, kateri del rastline je korenje, krompir, čebula ali cvetača. Ko otroci spoznajo, kaj je plod in kaj ni, ostale plodove začnejo razvrščati po različnih kriterijih. Pogosto izberejo za kriterij barvo ali obliko.

Barva

Pomembno je, da damo v zbirko plodove iste vrste, vendar različnih barv ali oblik. Tako naj bodo jabolka zelena, rdeča, rumena. Razlikujejo naj se tudi po obliki in po otipu lupine (na primer kosmač). Prav tako lahko damo v zbirko paprike različnih barv, oblik in velikosti. Tako otroci vidijo, da pride vsako jabolko, ki je drugačne barve, v svojo skupino, čeprav so vsi plodovi jabolka. V posamezni barvni skupini pa lahko uvedemo tudi urejanje, tako da otroci uredijo plodove od najbolj rdeče do najmanj rdeče.

Oblika

Če je kriterij oblika, bo večina jabolk v isti skupini, ne glede na barvo, saj so bolj ali manj iste oblike. Podobno lahko naredimo tudi s papriko. Tudi papriko lahko otroci razvrstijo po barvi. Če je kriterij oblika, pa dobimo najmanj tri skupine (podolgovate, okrogle in nepravilne). V skupini okroglih plodov bodo jabolka, paradižnik, grenivka, pomaranča, breskev. Med podolgovatimi plodovi bodo kumare, bučke, banane, čili, sladka paprika. Med nepravilnimi bosta, na primer, hruška in jajčevec.

Velikost

Če plodove razvrščamo po velikosti, moramo najprej določiti srednjo vrednost. Vsi plodovi, ki so večji od srednje vrednosti, gredo v eno skupino, in tisti, ki so manjši od srednje vrednosti, gredo v drugo skupino. Kasneje lahko plodove tudi uredijo od najmanjšega do največjega.

Okus

Otroku lahko zavežemo oči in mu ponudimo različne koščke plodov, da jih razvrsti po kriteriju »všeč mi je » ali »ni mi všeč«. Lahko pa jih tudi prepoznava po okusu.

Vonj

Prav tako lahko z zavezanimi očmi otroci prepoznavajo plodove po vonju. Kriterij je, ali mi je vonj všeč, ali ne. Mnogo teže pa je prepoznavanje plodov po vonju.

Tip

Tudi prepoznavanje plodov po otipu izvedemo z zavezanimi očmi. Otroci morajo vedeti, kaj je gladko in kaj hrapavo. Nekateri otroci ugotovijo, da so plodovi mehki, vlažni, trdi ali suhi. Tako lahko pri tej dejavnosti otroci bogatijo besedni zaklad.

Teža

Otroci lahko plodove razvrščajo po teži. Pri tem potrebujejo prevesno tehtnico. Zopet določimo srednjo vrednost. Vsi plodovi, ki so težji od srednje vrednosti, gredo v eno skupino, drugi, težji, v drugo skupino. Zopet lahko na koncu plodove uredimo od najtežjega do najlažjega.

Plovnost

Otroci lahko najprej napovedo in naredijo seznam, kateri plodovi bodo po njihovem mnenju plavali in kateri ne. V kadičko polagajo plodove in ugotavljajo plovnost. Rezultate vnesejo v razpredelnico in primerjajo napoved z zaključenim poizkusom.

Tako otroci spoznavajo, kaj so plodovi, in z različnimi čutili ugotavljajo, po čem se razlikujejo. Na koncu lahko otroci plodove narišejo, pobarvajo in poimenujejo. Aktivnosti lahko razširimo z razmišljanjem, zakaj nekateri plodovi pri nas uspevajo in nekateri ne. Pogovarjamo se o pogojih za rast, kakšno temperaturo in vlago potrebujejo različne vrste rastlin, katerih plodove uživamo, in kako pripeljejo plodove do nas. Zakaj nekatere rastline, ki niso pri nas domorodne, uspevajo in nekatere ne.

Na koncu vseh dejavnosti lahko naredijo sadno solato in uživajo v različnih okusih in vonjavah.

DISKUSIJA

Te aktivnosti smo večkrat preizkusili z učenci različnih starosti kot tudi s študenti in učitelji in vzgojitelji. Učitelji so razvrščali po drugačnih kriterijih kot otroci. Predvsem so učitelji uporabili kriterij »sadje in zelenjava«, za katerega pa nimamo natančne definicije in je zato delitev zelo težka, čeprav se uporablja v vsakdanjem življenju. Prav tako so imeli tako otroci kot učitelji težave pri določanju, kaj je zemeljski oreščєk, ali je plod ali je podzemno steblo. Čeprav smo se pogovorili, kaj je definicija ploda, mnoge zavede, da se plod ne more razviti v prsti.

Kako velika naj bo zbirka plodov, je odvisno od tega, kaj želimo s temi dejavnostmi doseči in od starosti otrok. Za krajšo dejavnost je dovolj, da prinesemo zbirko različnih jabolk, ki se razlikujejo po obliki, velikost, barvi, zgradbi lupine in okusu.

V zbirko v višjih razredih lahko dodamo plodove različnih gozdnih dreves. Lahko se pogovarjamo o tem, kako se raznašajo plodovi v naravi in kakšne imajo prilagoditve, da jih lahko raznaša veter, živali, voda ali človek. Nekateri imajo samosprožilne mehanizme. Plodovi, ki jih raznaša veter imajo različne letalne pripomočke, s katerimi jadrajo po zraku. Lahko ugotavljamo, kako daleč letijo plodovi, če jih spustimo z določene višine. Tako otroci spoznajo različne načine raznašanja plodov in njihovih semen. Pogovarjamo se tudi, zakaj je pomembno, da se semena razširjajo proč od matične rastline. Otroci plodove prerežejo in si ogledajo semena. Nekatere rastline imajo veliko semen, nekatera samo eno. Razlikujejo se ne samo po številu, ampak tudi po velikosti, obliki in barvi. Semena lahko otroci posadijo in ugotavljajo, kakšni so pogoji za uspešno kalitev semen. Opazujejo, koliko semen vzkali, zakaj nekatera semena ne vzkalijo in podobno. Dejavnosti s plodovi, kot smo jih opisali, pomagajo otrokom razvijati naravoslovne postopke, tako da znajo bolje opazovati razlike in podobnosti med organizmi. Tak način dela je za otroke bolj zanimiv, saj so sami vključeni v raziskovanje in s tem bolj motivirani in bolj radovedni. Pomembno je tudi, da otroci delajo s pravim materialom in ga lahko spoznavajo z različnimi čutili. Učitelju ni potrebno natančno opisovati značilnosti plodov, ampak otroke samo usmerja v spoznavanje in doživljanje narave.

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OBSERVE, COOPERATE, DESCRIBE
/
OPAZUJEM, SODELUJEM, OPISUJEM

Tanja Bervar

OŠ Frana Albrehta

bervar.tanja@gmail.com

Danica Mati Djuraki

OŠ Frana Albrehta

danica.mati@guest.arnes.si

ABSTRACT

Teachers often ask themselves how to teach so that pupils will learn in an interesting and effective way. We want to find out how to approach scientific subjects to pupils and how to overcome the stereotypical image of children that scientific subjects are too difficult, uninteresting and useless for life or further education. The aim of the presentation is to show one of the methods how to overcome or facilitate this problem. Meanwhile, we want to build the so-called vertical link among scientific educational themes from the first to the seventh grade of Science. Consequently, we focus on a pupil learning to observe, actively cooperate and describe natural phenomena and processes around him/her.

Keywords: *observe, cooperate, describe, Science, vertical link*

UVOD

Spoznavanje narave, tehnološkega okolja ter življenjskih in tehnoloških procesov igra pomembno vlogo pri vzgoji, izobraževanju in oblikovanju osebnostnih lastnosti mladega človeka. Cilj današnje vzgoje je razviti učenca kot ustvarjalno bitje, ga naučiti samostojno razmišljati in pridobivati novo znanje, ga motivirati za vseživljensko učenje in vzpostaviti pristen stik z okoljem. V učnem procesu učenci prihajajo do različnih spoznanj z neposrednim opazovanjem narave in okolja. Na tem temelji pouk naravoslovnih ved.

Na predmetni stopnji od šestega do devetega razreda učitelji opažamo, da so naravoslovni predmeti manj priljubljeni, učenci imajo pred njimi predsodke, pogosto so prepričani, da so ti predmeti težki in da jih preprosto nikoli ne bodo razumeli. Napačna prepričanja izvirajo od doma, pa tudi od starejših vrstnikov.

Z zanimivimi dnevi dejavnosti v nižjih razredih osnovne šole in tradicionalnimi zanimivimi novoletnimi poskusi želimo učencem pokazati, da je lahko naravoslovje zanimivo in nič zapleteno.

METODA

Delo je potekalo v razredih prve in druge triade osnovne šole. V raziskavo je bilo vključenih 160 učencev iz OŠ Frana Albrehta Kamnik. Izbrane teme so spoznali s skupinsko učno obliko, samostojnim ter demonstracijskim delom. Pri tem so bili vključeni vsi trije učni stili; tako vizualni, aditivni in kinestetični. Izvedeni so bili štirje naravoslovni dnevi z naslovom Opazujem, sodelujem, opisujem in Novoletni eksperimenti. Pri načrtovanju so sodelovali učiteljice naravoslovja in učiteljice, ki poučujejo v prvih dveh triadah. Učne teme so bile izbrane glede na letni učni načrt posameznih razredov zato je naravoslovni dan lažje vključiti v letni delovni načrt razreda. Po opravljenih dejavnostih smo z anketo povprašali učence in učiteljice po mnenju o naravoslovnem dnevu.

REZULTATI

Novoletne poskuse na naši šoli izvajamo že dlje časa. Letos smo povprašali učence, ki so izbrali izbirni predmet poskusi v kemiji, kaj je vplivalo na njihovo izbiro. 60 % učencev se je za ta predmet odločilo zaradi novoletnih poskusov, 10 % pa zardi učiteljice, ki je novoletne poskuse izvedla.

Učitelji, pri katerih smo izvedli naravoslovne dneve, vidi največjo prednost le teh v sodelovanju med učitelji v prvi in drugi triadi z učitelji naravoslovja. Podobnega sodelovanja si želijo več, razširili bi ga tudi na sodelovanje pri drugih naravoslovnih temah, obravnavanih pri rednih urah. Izbrane teme so se jim zdele dobre, želijo pa si več vpliva na izbiro tem. Menijo, da so se učenci dobro odzvali na dejavnosti, čeprav so bila pričakovanja nekoliko višja. Menijo, da tovrstno delo ne vpliva na učenčevo razmišljanje o naravoslovnih predmetih.

Učenci so naravoslovne dneve ocenili zelo dobro, večinoma z najvišjo ali drugo najvišjo oceno. Na vprašanje, kaj jim je bilo najbolj ali najmanj všeč, so bili odgovori zelo razpršeni; nekoliko izstopajo kemijske vsebine (60 %). Menimo, da smo pokrili raznolike teme in s tem zadovoljili želje različnih učencev. Mnogim je bilo zelo všeč (75 %), da so lahko sami eksperimentirali.

ZAKLJUČEK

Izkušnje s sodelovanjem so zelo dobre. Podobno kot spremljamo učinek novoletnih poskusov na izbiro izbirnih predmetov, bomo v prihodnje spremljali vplive tovrstnih naravoslovnih dni na odnos učencev do naravoslovja ter se trudili, da bi ohranili in izboljšali sodelovanje učiteljev.

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TRENDS IN ICT AND MULTIMEDIA BASED EDUCATION
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TRENDI NA PODROČJU IZOBRAŽEVANJA Z UPORABO IKT IN MULTIMEDIJE

Janez Bešter

Univerza v Ljubljani, Fakulteta za elektrotehniko

janez.bester@fe.uni-lj.si

Marko Papić

Univerza v Ljubljani, Fakulteta za elektrotehniko

marko.papic@ltfe.org

Andrej Gregorc

Univerza v Ljubljani, Fakulteta za elektrotehniko

andrej.gregorc@ltfe.org

Rok Žurbi

Univerza v Ljubljani, Fakulteta za elektrotehniko

rok.zurbi@ltfe.org

ABSTRACT

Amount of information and resulting knowledge needed for competitive inclusion of any individual or institution into knowledge society is rising constantly. At the same time, life span of knowledge is decreasing. Lifelong learning is playing very important role in the modern times, as almost any individual, independent of age or occupation is required to gain new knowledge over and over. Changes and adaptations of traditional learning methods and educational systems are needed in order to prevent the divide between those that have the knowledge needed and those that don't. It is important to state that each individual starts learning within the formal educational system. Adaptation of elementary educational system is therefore most important and will have positive consequences on all other educational systems that individuals meet during lifetime. Changes and adaptations of educational systems are very much related to ICT, which can act as a tool that fosters these changes, also they should be implemented because of completely different reasons.

Supporting ICT and Multimedia are in many cases mature enough to be systematically introduced into educational process. It is not only about making education more appealing, but also due to reasons of increasing effectiveness in education. Use of ICT is oriented towards constructive learning, whereas in many cases learning goals can be achieved easier and faster. Use of ICT in education also decreases digital divide and increases competitiveness of work force.

In this article, all aspects of systematic ICT introduction into education are presented. Necessary organizational changes, as well as modern pedagogical approaches, enabled by the use of ICT are described. The article focuses on the changing role of educational practitioners and presents complete ICT and multimedia supported educational system, ranging from technologies, virtual and real environments as well as content and support needed. Important issues that prevent necessary changes of educational systems on the bigger scale are described and commented upon.

Keywords: *ICT supported learning, Multimedia, E-learning 2.0, Web 2.0, Virtual Community, National Educational Portal, User Generated Content, E-portfolio, E-course, Virtual Classroom, Knowledge Building, Knowledge Management, Game Based Learning*

UVOD – ŠOLSKI SISTEM DANES IN JUTRI

Šolski sistem kot ga poznamo in v veliki meri uporabljamo še danes je nastal sredi 19. stoletja kot odgovor na »odsotnost staršev z doma« zaradi njihove zaposlitve v tovarnah. V času razvoja industrijske družbe je bil prilagojen »vzgajanju« delovne sile, ki ji je bilo potrebno vcepiti določena znanja in sposobnosti, ki so bile potrebne za življenje in so vključevale le elementarna znanja. Znanja, ki so jih potrebovali na svojem delovnem mestu in v življenju po šolanju, pa so praviloma vključevala repetitivne aktivnosti in se niso spreminjala.

Šolski sistem je bil narejen po principu »one size fits all«, torej je združeval npr. 30 povsem različnih posameznikov in jim ponudil popolnoma enake vsebine in didaktične metode. Tu nastopi eden izmed osnovnih problemov, saj so ljudje v osnovi različni, torej nadarjeni za različna področja učenja in dela, z različnimi željami in značaji, formalni šolski sistem pa še danes v večini temelji na predpostavki, da so vsi enaki.

Tak sistem izobraževanja je doživel svoj vrhunec tekom 20. stoletja in je ostal praktično nespremenjen do danes, navkljub popolnoma revolucionarnim tehnološkim spremembam, ki so se v tem času zgodile na vseh ostalih področjih dela in življenja.

Predmetniki v šolah so še vedno večinoma namenjeni pridobivanju znanj repetitivne narave in ne pridobivanju znanj/veščin, ki so dejansko potrebne oziroma zaželjene v vsakdanjem življenju in delu. Izobraževalni programi v veliki meri ne odražajo potreb podjetij in veščin, ki jih le-ta pričakujejo od svojih bodočih sodelavcev. Tako nastaja razkorak med pričakovanji in zahtevami delodajalcev ter dejanskm znanjem in usposobljenostjo kadrov (ang. credibility gap).

Precejšen problem v šolskem sistemu predstavlja tudi zastarelost in neprimernost ocenjevalnega sistema, ki zgolj preverja sposobnost reprodukcije že poznanih dejstev do neke določene odstotne stopnje, ki naj bi zadostovala za strokovno usposobljenost.

V okviru največjega svetovnega dogodka s področja tehnološko podprtega izobraževanja, EDUCA-ONLINE, ki vsako leto poteka v Berlinu, Nemčija, je bila ena izmed osnovnih ugotovitev plenarnih diskusij, da obstoječi šolski sistemi v Evropi v večini niso sposobni ponuditi »vizije sveta«, ampak zgolj »svet tak kot je«.

V okviru zgoraj navedenih trditev, je potrebno ponuditi sistemske rešitve, ki bodo prilagodile formalne sisteme izobraževanja. Šole, na vseh stopnjah višjih od osnovne, bi morale ponujati vsebine, predvsem pa pedagoške pristope izobraževanj, ki bi bili prilagojeni potrebam in željam učencev. Šolski sistem bi moral vzpodbujati pluralnost in dajati navdih vsem, ki si upajo in zmorejo misliti drugače od uniformirane večine. V sami osnovi ne sme vzpodbujati zgolj tistih, ki so sposobni odličnega branja in pisanja, ampak tudi vseh, ki se lahko izražajo ali razmišljajo na druge načine in odstopajo od uveljavljenega povprečja. Tako je ključnega pomena identificirati, oziroma razlikovati »sposobnost učenja« od »nadarjenosti«. Prvo je veščina, ki se jo je mogoče priučiti, drugo je redka lastnost izjemnih posameznikov. Prilagajanje izobraževalnega sistema tako zahteva organizacijske spremembe, ki po eni strani poudarjajo samostojnost, po drugi strani pa hitro odzivnost na spremembe, ki v sodobnem času, poleg individualnosti, dajejo poseben pomen skupinskemu delu na vseh področjih.

INOVATIVNI DIDAKTIČNI PRISTOPI IN IKT (UČITELJ NE POUČUJE, TEMVEČ MODERIRA IN POMAGA!)

Kot opisano že v uvodu inovativni didaktični pristopi temeljijo na konstrukciji oziroma izgradnji znanja.

Kot najbolj pomembne lahko izpostavimo različne oblike sodelovalnega oziroma projektnega dela učencev, ki se zaključi z določenim izdelkom. Če so pri tem uporabljene sodobne IKT, ki praviloma (ob primerni uporabi) predstavljajo dober motivacijski vzvod, je možno take načine učenja izvajati v širšem obsegu kot v preteklosti. Čas, ki je potreben od procesa učenja do končnega izdelka, je lahko veliko krajši, sodobne tehnologije pa omogočajo enostavno izdelavo digitalnih vsebin s strani udeležencev (ang. user generated content). Kot pomembno prednost uporabe IKT lahko izpostavimo tudi možnost enostavnega in prostorsko neomejenega deljenja izdelkov z drugimi učenci.

Inovativni didaktični pristopi lahko temeljijo tudi na izvedbi specifičnih učnih ur, podprtih z IKT kot učnim pripomočkom in orodjem, ter multimedisjkimi vsebinami pripravljenimi posebej za izvedbo. Kot primer lahko navedemo uporabo digitalnih izobraževalnih iger v učnem procesu. Digitalne igre, oziroma igre nasploh, imajo velik motivacijski potencial, saj ob uporabi sodobne terminalne IKT opreme praviloma obsegajo tudi zanimivo vsebino, ki ustvari poseben “navidezni svet” in igralca povsem prevzame (ang. immersive activity). Različni tipi obstoječih iger, od repetitivnih, iger, kjer igralec prevzame določeno vlogo, do pustolovskih in raziskujočih so lahko ob prilagoditvah zelo dobro uporabljive v izobraževalnem procesu. Igrajo jih lahko posamezniki ali pa skupine, v živo, oziroma na daljavo preko spleta.

Če k takemu načinu izvedbe učnih ur dodamo še komponento mobilnosti, ki jo odraža uporaba mobilne IKT terminalne opreme in brezžičnega dostopa do spleta (vsebin), lahko učni proces izvajamo s pomočjo iger ali sodelovalnega dela tudi v realnem svetu izven učilnic in se tako izognemo potencialnim nevarnostim uporabe iger oziroma IKT (preveč časa porabljenega za zaslonom računalnika in izguba stika z realnostjo ter socialne komponente osebne interakcije).

Poleg opisanih obstaja še cela vrsta prilagojenih inovativnih didaktičnih pristopov, ki jih je možno izvajati s pomočjo IKT. Sodobne terminalne naprave (elektronske table, dlančniki, bralniki, pametni mobilni telefoni), programska oprema, digitalne multimedijske vsebine, elektronsko preverjanje znanja, ipd., omogočajo izvedbo prilagojenih učnih ur, ki popestrijo učni proces. Hkrati omogočajo izgradnjo znanja povezanega z rezultati in izdelki učne ure in nenazadnje pridobivanje drugih, mehkih veščin (sodelovanje v skupini, spoznavanje tehnik učenja, razločevanje ter kritično vrednotenje relevantnih podatkov in informacij in drugo).

Za vse opisane pristope je značilna sprememba vloge učitelja. Le-ta ni več zadolžen izključno za poučevanje, temveč za podporo in izvajanje moderiranja učnega procesa. Sprememba vloge učitelja se neposredno odraža tudi na načinu dela, pripravi učnih ur in pri sami izvedbi. Pogosto to pomeni potrebo po večji inovativnosti izvajalcev, v praksi pa to pomeni več časa potrebnega za pripravo učnih ur, prilagajanje potrebam posameznih učencev in manj ustaljenih repetitivnih aktivnosti. Vse to rezultira v potrebi po prilagajanju celotnega šolskega sistema. Delo izvajalcev je potrebno prevrednotiti, poenostaviti administrativne in druge aktivnosti, ki se ne nanašjo na pedagoško delo in jim predvsem omogočiti vse pogoje, da se lahko primerno odzovejo na sodobne razmere.

IZOBRAŽEVALNI PROCES IN IKT (E-ŠOLA NI NAVIDEZNA ŠOLA!)

V predhodno zapisanih potrebah po spremembah šolskega sistema kot tudi izvedbe učnega procesa imajo IKT in multimedija lahko poseben pomen kot učinkovito podporno okolje in orodje(a) za uveljavitev sprememb na vseh ravneh izobraževalnega procesa. Za množico tehnologij, storitev in vsebin lahko rečemo, da so v današnjem času že preizkušene in uporabljive v izobraževalnem procesu. Hiter razvoj na tem področju zahteva nenehno uvajanje, ocenjevanje in preizkušanje novih. V nasprotnem primeru se lahko zgodi, da z formalni izobraževalni proces močno izgubi stik s potrebami sodobnega časa.

Ko govorimo o IKT podprtem učenju, naslavljamo več ravni in sicer:

- raven izvajalcev izobraževalnega procesa,
- raven udeležencev (učencev, dijakov, študentov).

Na ravni izvajalcev izobraževalnega procesa je potrebno zagotoviti predpogoj za uspešno uporabo IKT. Ta predpogoj se nanaša na informacijsko pismenost izvajalcev, ki ni nujno enaka informacijski pismenosti ostale populacije. Informacijska pismenost učiteljev mora odgovoriti na vprašanje, kako učinkovito uporabiti sodobne IKT in multimedijo z didaktičnega stališča, samo poznavanje delovanja tehnologij, storitev in vsebin pa pri tem ni ključnega pomena. IKT in multimedija sta le učinkovito orodje, šele pravilna uporaba le-tega pa ustvari dodano vrednost v izobraževalnem procesu.

Sistematsko usposabljanje najširšega kroga izvajalcev formalnega izobraževanja za rabo IKT je zato prerdpogoj za učinkovito uporabo IKT. To usposabljanje mora potekati v osnovni in “nadaljevalni” obliki. Osnovno izobraževanje naj bo modularno (z izbirnimi vsebinami), a enako za vse izvajalce ne glede na predmetno področje. Osnovnega usposabljanja po izkušnjah držav, ki tako obliko izvajajo že več let, ni možno izvesti v obliki kratkih delavnic v živo, temveč predvsem v obliki večmesečnega praktičnega dela (praktične uporabe sodobnih IKT) in dela na daljavo. Napredno usposabljanje naj bo usmerjeno na prilagojeno uporabo izbranih IKT v določenih predmetnih področjih in ravneh izobraževanja, poteka pa lahko v obliki kratkih, eno ali večdnevnih delavnic oziroma tudi na daljavo. Enako pomembno je redno obnavljanje in posodabljanje pridobljenih znanj, četudi je le-to časovno in finačno enako zahteven zalogaj.

V Sloveniji to področje zaenkrat, kljub velikemu številu kratkih in raznolikih usposabljanj, ni sistemsko urejeno, zato bi se veljalo zgledovati po nekaterih evropskih državah, ki imajo s sistemsko uvedbo IKT usposabljanj za učitelje desetletne izkušnje, in prenesti primere dobre prakse ter jih prilagoditi na specifičnosti slovenskega šolskega sistema.

Opisani predpogoj, e-kompetentni izvajalec izobraževalnega procesa, predstavlja podlago za uspešno uporabo inovativnih didaktičnih pristopov s podporo IKT in multimedije, saj se izvajalci z omenjenimi pristopi v praksi praviloma srečajo že v času usposabljanja in jih po opravljenem usposabljanju le bolj redno in uspešno (s pridobljenimi izkušnjami) uporabljajo v izobraževanju.

Na ravni udeležencev (učencev) v izobraževalnem sistemu je digitalna / informacijska pismenost enako pomembna kot na ravni izvajalcev, vendar ima druge poudarke.

Sposobnost uporabe novih tehnologij in medijev mora biti povezana z zmožnostjo kritičnega sprejemanja, vrednotenja in povzemanja informacij, pridobljenih s pomočjo (uporabniško-generiranih in drugih) baz podatkov ter informacijskih virov, ki so na voljo. Sposobnost uporabe je znova le predpogoj, opisane zmožnosti pa so predmet uvedbe in izvedbe inovativnih didaktičnih pristopov, ki učence privajajo na način sprejemanja znanja kot je opisan predhodno.

V nadaljevanju so, poleg IKT prilagojenega upsosabljanja, opisane štiri pomembne komponente, ki morajo biti podprte zavoljo uspešne uporabe IKT v v formalnem izobraževalnem procesu. To so:

- multimedijske vsebine izobraževanja,
- sodobno spletno izobraževalno okolje,
- tehnična in strokovna didaktična podpora in
- aktivno sodelovanje z razvojno raziskovalnim sektorjem.

MULTIMEDIJSKE VSEBINE IZOBRAŽEVANJA

Multimedijske vsebine predstavljajo alternativo obstoječim vsebinam v izobraževalnem procesu. Tako je poudarek na izobraževalnih vsebinah, ki jih je možno digitalno predstaviti v vizualno privlačni obliki, ter jim dodati interaktivnost. Predstavitev vsebine v digitalni obliki ni potrebna le zaradi vizualne privlačnosti, temveč predvsem zaradi lažje razumljivosti, pogosto pa predstavitev vsebine v digitalni obliki odpre različne poglede na vsebino, ki jih s klasičnimi metodami prikaza (učbeniki) enostavno ni mogoče izvesti. Interaktivnost vsebine, oziroma zmožnost vplivanja učencev na vsebino in odziv vsebine je enako pomemben razlog za izdelavo multimedijskih vsebin. Nenazadnje sodobne IKT in multimedija omogočajo daljinsko dostopnost izobraževalnih vsebin, komurkoli, kadarkoli in od koderkoli.

Multimedijske vsebine lahko razdelimo na tri osnovne tipe:

- e-učbeniki,
- specifične multimedijske vsebine, ki se nanašajo na izbrano ožje predmetno področje, so prilagojene uporabi specifične IKT ali pa specifičnega didaktičnega pristopa in
- uporabniško generirane vsebine izvajalcev in učencev.

E-UČBENIKI

E-učbeniki so profesionalne vsebine, ki celovito pokrivajo predmetna učna področja, vsebino pa predstavljajo z uporabo interaktivnih multimedijskih gradnikov, naprednih digitalnih animacij in videom, kjer je to možno in zaželjeno. Za e-učbenike je potrebno ustvariti enakovredno okolje kot za klasične učbenike, kar v praksi pomeni, da bi njihova uporaba morala biti enakovredna uporabi klasičnih učbenikov. Poleg didaktične vrednosti razvoj e-učbenikov pomeni tudi občutno zmanjšanje stroškov in povečanje enostavnosti popravljanja in posodabljanja le-teh. Osnovni razvoj e-učbenika sicer predstavlja finančno večji zalogaj kot v primeru klasičnih učbenikov, vendar pri e-učbenikih ni stroškov vsakokratnega tiskanja, njihova dostopnost pa je enaka za vse, tako da se glede na velikost ciljne skupine učencev investicija v e-učbenike povrne v nekaj letih.

Uvedbo e-učbenikov mora spremljati sistemski pristop na nacionalni ravni, ki vključuje procese evalviranja in potrjevanja, hkrati pa je potreben razvoj tehnloškega okolja, v katerem bodo ti učbeniki uporabljeni tako s stani učiteljev kot tudi učencev. O sodobnem spletnem izobraževalnem okolju bo govora v naslednjem poglavju prispevka.

SPECIFIČNE MULTIMEDIJSKE VSEBINE

Specifične multimedijske imajo drugačen pomen in drugačne vidike uporabe v izobraževalnem procesu. Praviloma so to digitalne vsebine prilagojene za uporabo na določenem mediju. Kot primer lahko navedemo vsebine, prilagojene za delo z elektronsko tablo, ki so drugačne od vsebin namenjenih svetovnemu spletu, biti morajo bolj interaktivne, uporabljati prednosti kot tudi omejitve medija. Podobno velja za vsebine namenjene prikazu na mobilnih telefonih. V Sloveniji je bil za take digitalne izobraževalne vsebine uporabljen izraz "didaktična programska oprema".

Kot naslednja primera specifičnih vsebin so tudi vsebine digitalnih izobraževalnih iger, opisanih v predhodnem poglavju, ali pa samostojni profesionalni kratki video posnetki namenjeni vizualnemu prikazu izbrane vsebine v okviru učnih ur.

Specifične multimedijske vsebine presegajo okvir e-učbenikov, vendar sta njihov razvoj in izvedba ključnega pomena za izvedbo učnih ur, temelječih na inovativnih didaktičnih metodah in uporabi IKT. Specifične vsebine tako lahko obravnavamo kot potreben dodatek k e-učbenikom, njihov razvoj pa bi moral biti vključen v sistemskem pristopu uvedbe e-učbenikov na nacionalni ravni.

UPORABNIŠKO GENERIRANE VSEBINE

Le-te je potrebno obravnavati v smislu razširjanja uporabe IKT v učnem procesu in večjega vključevanja tako izvajalcev kot tudi udeležencev. Njihov razvoj je možen zavoljo uvajanja sodobnih razvojnih orodij, ki so vse bolj dostopna in enostavna za uporabo. Enako pomemben dejavnik je možnost deljenja uporabniško generiranih vsebin in posledično ustvarjanja in ohranjanja skupnosti izvajalcev kot tudi učencev z enakimi strokovnimi interesi, področji dela, hobiji, ipd. Izvajalci svoje uporabniško generirane vsebine lahko uporabljajo kot učne pripomočke za lastne potrebe, učencem pa lastne uporabniško generirane vsebine predstavljajo pomemben rezultat njihovega dela. Pri tem se znova soočimo z izzivom uvedbe sodobnega spletnega izobraževalnega okolja, ki mora na enostaven način podpreti vse procese povezane z ustvarjanjem in ohranjanjem skupnosti kot tudi nastajanjem in deljenjem uporabniško generirane vsebine.

SODOBNO SPLETNO IZOBRAŽEVALNO OKOLJE

Ko govorimo o sodobnem spletnem izobraževalnem okolju obravnavamo skupino povezanih različnih, porazdeljenih spletnih aplikacij. Spletne aplikacije lahko delimo glede na osnovno namembnost:

- aplikacije za dostop do podatkov, informacij, vsebin in znanja,
- aplikacije, s pomočjo katerih se izvaja izobraževalni proces (učno okolje).

V prvem primeru so to aplikacije, praviloma zbrane v okviru **nacionalnega izobraževalnega portala**. Izobraževalni portal je sestavljen iz več spletnih mest, kjer uporabniki dostopajo do specifičnih multimedijskih vsebin. Pri tem lahko izpostavimo video vsebine, vsebine za elektronske table in izobraževalne igre. Portal obsega tudi spletna mesta namenjena vzpostavitvi in vzdrževanju e-skupnosti učencev kot tudi izvajalcev z istimi interesi.

Nacionalni izobraževalni portal mora omogočiti dostop do tehnične in strokovno didaktične podpore, namenjene predvsem izvajalcem izobraževalnega procesa kot tudi učencem. Še najbolj pomembno je, da obsega enostavne in učinkovite iskalniške storitve, ki brskajo po nacionalni bazi e-vsebin, kot tudi po drugih primernih virih. Nacionalni izobraževalni portal predstavlja tudi vstopno točko do aplikacij, ki omogočajo informacijsko podporo izobraževalnemu procesu. To so lahko spletne redovalnice in različne aplikacije namenjene administrativnim aktivnostim izvajalcev izobraževalnega procesa. Celovito obravnavan portal tako omogoča tudi aktivno vključevanje staršev, ki so lahko bolje in ažurneje seznanjeni s potekom učnega procesa.

Učno okolje je sestavljeno iz porazdeljenih aplikacij, ki omogočajo izvedbo učnega procesa s pomočjo spletnih tehnologij in storitev. Ključne dejavnosti, ki naj jih sodobno učno okolje podpira, se nanašajo na orodja za razvoj vsebin, spletne učilnice, orodja namenjena komunikaciji, sodelovanju ter skupinskemu oziroma projektnemu delu, elektronsko preverjanje znanja, orodja za enostavno izgradnjo portfeljev učencev in učiteljev. Opisana orodja in okolja so podprta tudi z administrativnimi orodji, namenjenimi upravljanju izobraževalnega procesa, sledenju napredovanja uporabnikov ter evalvaciji poteka spletnega izobraževalnega procesa.

TEHNIČNA IN STROKOVNA DIDAKTIČNA PODPORA

Do zdaj smo govorili o vsebinskih aspektih in podpornih orodjih, ki omogočajo učinkovito izrabo IKT v izobraževalnem procesu in predstavljajo potrebne, vendar ne zadostne pogoje za široko uporabo IKT. Izvajalcem izobraževalnega procesa, ki uporabljajo omenjene tehnologije, storitve in vsebine je ob tem potrebno nuditi tudi primerno tehnično in strokovno didaktično podporo. V ta namen je potrebno zasnovati učinkovit **organizacijski model podpore in svetovanja**.

Tak model naj v osnovi vključuje kompetentne institucije, to so lahko svetovalna podjetja, akademske institucije, kot tudi izobraževalne institucije (npr. šole), ki imajo med zaposlenimi napredne posameznike, izvajalce izobraževalnega procesa. Prav ti, s svojim poznavanjem ciljnega okolja, lahko nudijo zelo kvalitetno podporo, vendar je v organizacijskem modelu nujno vzpostaviti medinstitucionalno sodelovanje in ne le sodelovanje na ravni posameznikov. Organizacijski model vključuje tudi vidike evalvacije in stalnega zagotavljanja kvalitete.

Podpora izvajalcem izobraževalnega procesa poteka na različne načine. Primeri dobre prakse kažejo, da je najboljša podpora tista, v kateri institucije, ki nudijo podporo, izvajajo mini projekte z izvajalci izobraževalnega procesa z uporabo izbranega pedagoškega pristopa ter IKT. Učitelji skozi praktično delo pridobijo največ kompetenc in izkušenj. Drugi vidik podpore je klasičen, bodisi z uporabo različnih komunikacijskih orodij, ki so na voljo na nacionalnem izobraževalnem portalu, ali pa z izvedbo krajših usposabljanja oziroma svetovanj.

Na tem mestu želimo poudariti, da vloga izobraževalnega sistema ni nujno izobraziti svetovalce, ki bodo nudili tehnično in strokovno didaktično podporo, temveč poskrbeti, da bo najširši krog izvajalcev izobraževalnega procesa primerno usposobljen za uporabo IKT pri pouku. Svetovalce je možno črpati iz nabora že obstoječih podjetij in institucij, ki se ukvarajajo s tem področjem ter iz nabora naprednih učiteljev, ki pa morajo svojo kompetentnost izkazati s svojimi izkušnjami in znanjem.

AKTIVNO SODELOVANJE Z RAZVOJNO RAZISKOVALNIM SEKTORJEM

Področje uporabe IKT v izobraževalnem procesu je zelo dinamično in se nenehno spreminja, glede na uvajanje novih tehnologij in storitev. Glede na to, da se razvojno raziskovalni sektor z novostmi na področju IKT najprej srečuje v okviru svojih analiz in raziskav, je potrebno poskrbeti, da izobraževalni sistem tesno sodeluje z akademskimi organizacijami s tega področja. To sodelovanje je možno izvajati v okviru pilotnih projektov, za katere pa je še najbolj pomemben segment evalvacije in diseminacije, ki bo zagotovil, da bodo primeri dobre prakse hitro prešli v praktično uporabo.

ZAKLJUČEK

V današnjem času obstaja večje število IKT podprtih storitev in vsebin, ki so zrele za širšo uporabo v izobraževalnem procesu. Pri tem ne gre le za popestritev izobraževanja, temveč za konkretne učinke, ki vplivajo na večjo učinkovitost, lažje doseganje izobraževalnih smotrov in širše gledano za povečanje informacijske pismenosti, zmanjšanje digitalnega razkoraka ter povečanje konkurenčnosti in usposobljenosti kadrov.

Podobno kot v drugih primerih uvedbe IKT na področja življenja in dela, se tudi pri izobraževanju pokaže, da proces sistematske uvedbe, ki edini prinese rezultate, ni preprost. Če se ob uvedbi ne prilagodi tudi sam izobraževalni process, rezultati uvedbe praviloma niso zadovoljivi.

Prilagajanje izobraževalnega procesa ne sme potekati zaradi IKT, temveč zavoljo povsem netehnoloških razlogov. IKT predstavljajo le skupek orodij, ki omogočajo enostavno izvedbo pedagoških pristopov, ki jih v preteklosti s širokim krogom učencev ni bilo možno izvesti, oziroma je bila ta izvedba povezana z velikimi finančnimi vložki. Pri tem mislimo predvsem na individualno obravnavanje potreb in zmožnosti učencev oziroma prilagajanje izobraževalnega procesa potrebam posameznika kot tudi bolj izraženo potrebo po konstruktivističnih pristopih v izobraževanju, na vseh ravneh izobraževalnega procesa.

Sistematski pristop k uvedbi IKT ne obravnava posameznih tehnologij, storitev in vsebin, temveč gleda na proces uvedbe kot na celoto. Zato je potrebno vzpostaviti okolje, ki bo podprlo vse vidike uvedbe: vsebine, orodja, podporo in prihodnji razvoj.

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YOU CAN DONATE TO A CLEANER AIR? / ALI LAHKO PRISPEVAM K ČISTEJŠEMU ZRAKU?

Andreja Božič

OŠ dr. Aleš Bebler – Primož, Hrvatini

rlv.boz@gmail.com

Andreja Marzi

OŠ dr. Aleš Bebler – Primož, Hrvatini

marzi@siol.net

ABSTRACT

The article aims to demonstrate the technical day for students of the 9th class. We live in a time of declining stocks of fossil fuels is growing interest in renewable energy sources, which also include biomass. In the experimental work was used to determine how much heat emitted during combustion of different fuels. This was followed indirectly by measuring the temperature of the water to be heated to release heat from the burning of certain fuels. We also monitored the residue after burning of solid fuels. Samples of biofuels, which were used for experimental work were pellets, briquettes, sawdust, olive pulp, cherry pit (wet and dried), biodiesel, ethanol and fuel oil.

Keywords: *biofuel, biomass, technical day*

UVOD

Biomaso poimenujemo odmrli organski material, ki je v večini primerov rastlinskega izvora. Biomaso lahko uporabljamo za neposredno kurjenje, kot gorivo, pri čemer nastane toplotna energija.

Smo v obdobju, ko se zaradi vsestranske uporabe fosilnih goriv, počasi manjšajo njihove zaloge. Posledično pa vedno bolj narašča zanimanje za alternativne vire energije, med katere sodi tudi biomasa. Za oljčne tropine smo se odločili zato, ker živimo na območju, kjer pridelujejo oljčno olje in uporabljajo ostanke, ki nastanejo po stiskanju oljk, tudi kot gorivo v domačih pečeh za centralno ogrevanje. Kot gorivo pa se lahko uporabljajo tudi češnjeve koščice. V okviru tehniškega dne so učenci najprej teoretično spoznavali osnovne lastnosti biomase. V raziskovalnem delu pa so praktično s pomočjo eksperimentov ugotavljali: za koliko °C različna goriva segrejejo določeno količino vode in kolikšen je ostanek po gorenju trdnih goriv.

METODE

Pri delu z učenci smo uporabili naslednje metode: pregled in uporaba pisnih virov, eksperimentalno delo ter javna predstavitev rezultatov. Ugotavljali smo koliko toplote oddajajo pri gorenju različna goriva. To smo spremljali posredno, z merjenjem temperature vode, ki se segreje ob sproščanju toplote pri gorenju posameznega goriva.

Na list papirja smo zatehtali 20 g trdnega, oziroma 20 ml tekočega goriva v merilni valj. V aluminijasto posodico smo dali časopisni papir (0,9 g) in kurilno tabletko (3 g), tekoče gorivo pa smo nalili v gorilnik.

Na spodnje stojalo smo postavili posodico s trdim, oziroma gorilnik s tekočim gorivom, na zgornje stojalo pa mrežico in čašo s 50 ml vode. S termometrom smo izmerili začetno temperaturo vode in jo zabeležili. Nato smo prižgali kurilno tabletko in spremljali gorenje ter temperaturo vode. Odčitali smo jo vsakih 5 minut, temu je sledil zapis. Ko je vse gorivo zgorelo, smo zabeležili končno temperaturo vode in čas gorenja. Stehtali smo tudi maso ostankov po gorenju.

REZULTATI

Sprememba temperature vode pri uporabi različnih goriv

S poskusi smo ugotovili, da so goriva, kot so: etanol, nesušene češnjeve koščice in suhe oljčne tropine vodo najbolj segrela, in sicer za 70 °C. Najmanj se je voda segrela pri uporabi biodizla, le za 24 °C, pri ostalih uporabljenih gorivih pa je temperatura vode narasla za 43 do 63 °C..

Ostanek po gorenju trdnih goriv

Ugotovili smo, da so briketi skoraj popolnoma zgoreli, ostanka pri tem gorivu je najmanj. Največ ostanka po gorenju pustijo suhe oljčne tropine.

ZAKLJUČEK

Iz opravljenih poskusov smo ugotovili, da se toplota, ki jo oddajajo različne biomase pri gorenju razlikuje. Poleg tega nekatere biomase gorijo dlje, nekatere manj časa. Pri nekaterih vrstah biomase smo opazili, da temperatura nenehno narašča (etanol, kurilno olje, peleti, nesušene češnjeve koščice, nesušene oljčne tropine, suhe oljčne tropine), pri drugih pa doseže najvišjo možno temperaturo, nato pa začne upadati (biodizel, briketi, žagovina, suhe češnjeve koščice). Vsaka biomasa po gorenju pusti ostanek in sicer različno količino saj in pepela.

Prepletanje različnih metod dela je za učence zelo zanimivo, saj lahko aktivno sodelujejo pri izvajanju nalog, spodbuja jih k timskemu delu in aktivnemu razmišljanju. Ocenijo lahko svoja znanja in predvidevanja ter se učijo jasnega in javnega izražanja ugotovitev in svojega mnenja. Vse našteto, vključno z vsebino tehniškega dne, prispeva k večjemu zavedanju o pomenu odgovornega odnosa do sebe in drugih ter o dragocenosti narave in njenem varovanju.

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THE ROLE OF THE PHYSICS DEVELOPMENT GROUP IN RENEWAL OF SECONDARY SCHOOL PHYSICS EDUCATION
/
VLOGA PREDMETNE RAZVOJNE SKUPINE ZA FIZIKO PRI POSODABLJANJU GIMNAZIJSKEGA POUKA FIZIKE

Samo Božič

Zavod RS za Šolstvo

samo.bozic@zrss.si

ABSTRACT

The Physics development group together with mentoring teachers is responsible for creating a vision of the high school physics course, for implementing and monitoring the syllabus, raising the quality of physics education, for in-service teacher training and creating optimum educational opportunities for students. Great attention is given to the development and dissemination of examples of good teaching practice. Educational materials which are being developed will be published in a handbook for teachers and in our virtual classroom to which physics teachers have access.

Keywords: *physics, modernization of general upper secondary school, example of good teaching practice, teacher training*

UVOD

V okviru projekta Posodobitev gimnazije so Predmetne komisije za posodabljanje in uvajanje učnih načrtov pripravile posodobljene učne načrte, ki so se za prve letnike gimnazijcev začeli uporabljati v šolskem letu 2008/09. Po sprejetju učnih načrtov so se Predmetne komisije preoblikovale v Predmetne razvojne skupine (v nadaljevanju PRS), ki naj bi permanentno skrbele za posodabljanje gimnazijskega pouka. PRS za fiziko je ekspertna skupina, ki skrbi za kreiranje vizije predmeta, za uvajanje in spremljanje učnih načrtov, dvig kvalitete pouka, usposabljanje učiteljev in ustvarjanje optimalnih možnosti izobraževanja dijakov.

METODA

PRS za fiziko sestavljajo univerzitetni profesorji iz kadrovskih fakultet, učitelji praktiki in svetovalci Zavoda Republike Slovenije za šolstvo. V nadaljevanju so PRS k sodelovanju povabile mentorske učitelje, katerih glavna naloga je razvojno delo, preizkušanje novosti v praksi, priprava didaktičnih gradiv za pouk in njihovo preizkušanje, samoevalvacija in sodelovanje pri spremljavi. Mentorski učitelji nudijo pomoč PRS pri izvedbi usposabljanj za vse učitelje fizike.

Osrednja pozornost je namenjena razvoju in širjenju primerov dobre prakse. V prvi fazi je bila naloga skupine določitev področij delovanja in sicer:

- iskanje uveljavljenih tujih in domačih didaktičnih gradiv,
- priprava didaktičnih gradiv za aktivne oblike in metode dela,
- eksperimentalne vaje dijakov,
- informacijska in komunikacijska tehnologija pri pouku fizike,
- zanimive izbirne vsebine in medpredmetno povezovanje,
- kratke projektne in seminarske naloge ter
- sodobnejši načini preverjanja in ocenjevanja znanja.

Za potrebe delovanja skupine, zbiranja nastajajočih gradiv in komunikacije med člani na daljavo je bila odprta spletna učilnica. Za posamezna področja so bila zapisana izhodišča za oblikovanje gradiv in dodan prostor za njihovo zbiranje ter odprti forumi v podporo komunikaciji na daljavo.

Skupina se trenutno nahaja v fazi razvijanja in testiranja didaktičnih gradiv za pouk. Na začetku je vsak član pripravil tri primere didaktičnih gradiv, ki po njegovem mnenju sledijo ciljem posodobljenega učnega načrta in omogočajo:

- razvijanje zmožnosti naravoslovnega razmišljanja (premišljeno opazovanje, kritično razmišljanje, argumentiranje, vrednotenje, posploševanje, modeliranje, samostojno reševanje problemov)
- aktivno vlogo dijakov,
- diferenciacijo - dodane bodo naloge za bolj motivirane in zmožnejše dijake,
- da bodo naloge osnovnega nivoja praviloma zmogli izvesti vsi dijaki.

V naslednjem koraku je sledilo medsebojno recenziranje gradiv, popravki avtorjev in njihova predstavitev posameznih gradiv in primerov prakse. Nato je vsak član pregledal vsa gradiva in se ob vsakem gradivu opredelil med tremi možnostmi:

- bom zagotovo uporabil/a,
- bom mogoče uporabil/a in
- verjetno ne bom uporabil/a.

Po opravljeni analizi je sledilo ponovno vrednotenje gradiv s posebnim poudarkom na primerih, pri katerih se je večina odločila za uporabo in primerih, pri katerih se je večina odločila, da jih verjetno ne bi uporabila. Mentorski učitelji so nato gradiva preizkušali pri pouku in avtorjem pošiljali povratne informacije o izvedbi. Glede na vse pridobljene izkušnje so člani začeli pripravljati drugi krog didaktičnih gradiv.

REZULTATI

Rezultati delovanja PRS skupaj z mentorski učitelji se kažejo skozi sodelovanje pri izvedbi srečanj študijskih skupin in usposabljanju učiteljev. Na srečanjih člani posredujejo spoznanja in širijo izkušnje ter primere dobre prakse vsem učiteljem fizike.

Nastajajo didaktična gradiva za pouk, ki vsebujejo:

- tabelo s kazalniki, ki učitelju podajo prvo informacijo o gradivu (naslov, avtor, kratek opis za učitelje, cilji, priporočilo za oblike in metode dela, priporočilo za izvedbo, predviden čas za izvedbo, zahtevnost in vključenost eksperimenta),

- učne liste za dijake,
- napotke za učitelje z opisom in fotografijo potrebne opreme in
- rezultate.

Nekaj primerov dobre rabe in didaktičnih gradiv je že bilo in bo še prikazanih na usposabljanjih učiteljev. V nastajanju je priročnik za učitelje, ki bo vseboval teoretični del in okrog sto gradiv za sodobnejši pouk fizike. Gradiva bodo objavljena tudi na zgoščenki in v spletni učilnici, do katere imajo dostop učitelji fizike.

ZAKLJUČEK

PRS za fiziko ima osrednjo vlogo pri posodabljanju gimnazijskega pouka fizike. Skupaj s skupino mentorskih učiteljev v sodelovanju z Zavodom RS za šolstvo načrtuje sodobne pristope in načine uvajanja novosti in skrbi za posodabljanje gimnazijskega pouka fizike. Na seminarjih prenaša dobre izkušnje in primere dobre prakse ostalim učiteljem fizike. V sklepni fazi projekta bo naloga PRS skupaj s pedagoškimi svetovalci in mentorskimi učitelji načrtovanje in izvedba spremljave gimnazijskega pouka na fizike.

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MEASUREMENT
/
MERJENJE

Klavdija Brecelj

OŠ Ivana Roba Šempeter pri Gorici

klavdijabrecelj@gmail.com

ABSTRACT

Science subject teachers have perceived that pupils have problems with quantities and units of measurement. This abstract present a technical day – named »Measurement«. The pupils measured the length, area and volume with a non-standard and a standard unit. Before the measurement, each pupil wrote down the assessment of the sought quantity measurement. Their main goal was to connect the mathematical knowledge on measurement with experience and knowledge from other natural science fields and everyday life which would enable a better understanding and an easier way of solving problems. I have found out that this kind of work enables the pupils to use the known facts in a new situation and to acquire practical experience for a future understanding of abstract notions.

Keywords: *measurement, quantities of measurement, units of measurement, experience*

UVOD

V prispevku je prikazan tehnični dan »Merjenje«, ki sem ga izvajala v 7. razredu osnovne šole. Namenjen je bil merjenju dolžine, ploščine in prostornine. Učitelji opažamo, da učenci pogosto zamenjujejo enoto za mersko količino. K dani količini ne zapišejo pravih enot, ne poznajo pretvornikov med enotami iste količine in ne vedo, katere merske priprave uporabljamo za merjenje dane količine. Nimajo razjasnjenega pojma obseg in ploščina lika, ter površina in prostornina telesa. Obrazce za izračun naštetih količin se naučijo na pamet in jih pogosto zamenjujejo.

Zato je bil cilj tehničnega dne, da učenci matematično znanje o merjenju povežejo z izkušnjami in znanji iz drugih naravoslovnih področji, ter z vsakdanjim življenjem, kar bi jim omogočilo boljše razumevanje in lažje reševanje problemov.

METODA

Merjenje je naravoslovni postopek, pri katerem ugotavljamo, koliko izbranih enot vsebuje količina, ki jo merimo. Otroci se v vsakdanjem življenju že zelo zgodaj srečajo z merjenjem. Starši pogosto merijo njihove telesne razsežnosti: višino, maso, obseg pasu,…Med seboj se primerjajo in ugotavljajo, kdo je večji ali manjši, kdo je lažji ali težji,… Z merjenjem se srečajo tudi pri vsakdanjih opravilih: za pripravo peciva potrebujemo 4 jogurtove lončke moke, kruh smo spekli iz 1 kg moke, za obrobo prta je mama porabila 8m traku, darilo smo zavili v 1 polo papirja. Pri tem spoznajo standardne in nestandardne enote za merjenje količin.

Na razredni stopnji učenci najprej ocenjujejo in primerjajo količine, ter jih merijo z nestandardnimi enotami: s koraki, z dlanjo, s stopali,… Kasneje merijo dolžino, ploščino, prostornino in maso z standardnimi enotami. Meritve zapisujejo z merskim številom in mersko enoto, uporabljajo različne priprave za merjenje in s količinami računajo. Na razredni stopnji naj bi pouk slonel na izkušnjah otrok. Učenci naj bi razumeli proces merjenja in si pridobili predstave o velikosti obravnavanih enot. Zdi se mi zelo pomembno, da učenci na tej stopnji pridobijo predstave o dolžinskih enotah, saj jim to omogoča boljše predstave o enotah za merjenje ploščine in prostornine.

Enote za merjenje dolžine je na tej stopnji nujno povezati z deli telesa in tako krepiti predstave o dolžinskih enotah: 1m je razdalja med ramo in iztegnjeno roko pri odraslem človeku, 1 dm je razdalja med dvema iztegnjenima prstoma, 1cm je širina prsta, 1 mm je debelina nohta.

Na predmetni stopnji učitelji opažamo, da imajo učenci težave z velikostno predstavo posameznih enot. Učenci se odnosa med dvema enotama naučijo na pamet, zato pogosto prihaja do napak pri pretvarjanju mer. Le malo otrok na predmetni stopnji ima dobro razvite prostorske predstave, zato je potrebno tudi na predmetni stopnji izvajati določene aktivnosti in naloge, ter primere merjenj povezati z vsakdanjim življenjem.

REZULTATI

Učenci so bili razdeljeni v več skupin. Vsaka skupina je imela drugačno nalogo s področja merjenja. Dobili so liste z navodili za izvedbo naloge in ustrezne pripomočke. Delali so samostojno. Učitelj je imel le vlogo koordinatorja dela. Na koncu so poročali o svojem delu in naredili evalvacijo. Liste z nalogami sem učencem pobrala in ocenila njihovo delo.

Učenci so merili:

- dolžino: dolžino košarkarskega igrišča (s koraki), dolžino rokometnega igrišča (s palico),širino peskovnika (s papirnatim trakom), višino okna (s pedjo), dolžino gola (s palico), širino klopi (s slamico),

- ploščino: pravokotnika, ki ga sestavljajo ploščice pri umivalniku, panoja, šolske klopi, garderobnih vrat, vrat razreda, hodnika,

- prostornino: škatlice za čaj in predala, škatle za čevlje in omare, učbenika in omare, škatle riža in kartonaste škatle, škatlice zdravil (z zdrobom), akvarija (z vodo).

Vsak učenec je najprej zapisal svojo oceno meritve iskane količine. Nato so merili z nestandardno in s standardno enoto, ter meritve primerjali med seboj. Za merjenje ploščine so si izdelali m^2, dm^2 in cm^2, pri merjenju prostornine pa so si pomagali z enotskimi kockami. Računali so tudi obseg in površino.

Slika 1: Merjenje dolžine

Slika 2: Merjenje ploščine

Slika 3: Merjenje prostornine

ZAKLJUČEK

Učenci so si delo v skupini razdelili, Med seboj so komunicirali in se dogovarjali. Bili so mnenja, da so se s takim delom veliko naučili in si pridobili nove izkušnje. Ker so drug drugemu pomagali, so vsi rešili vse naloge. Ugotovili so, da sta učenca, ki sta merila dolžino igrišča vsak s svojo palico prišla do različnih rezultatov. Rezultat je bil odvisen od dolžine palice in njune natančnosti pri merjenju. Zaradi lažjega sporazumevanja je zato pri merjenju nujna vpeljava standardnih enot. Ugotovili so, da k merjenju dolžine spada tudi merjenje višine, širine in obsega, k merjenju ploščine pa površina teles. Pri nalogah so povezali enote za merjenje prostornine trdih teles z enotami za mejenje prostornine tekočin. Zelo radi so iz enotskih kock sestavljali telesa in jim določali prostornino.

Učenci so imeli najmanj težav pri ocenjevanju dolžin. Pri ocenjevanju ploščine in prostornine pa je pri nekaterih skupinah prišlo do večjih odstopanj med člani iste skupine. Skupina, ki je merila dolžino košarkarskega igrišča je dobila veliko razliko med izračunano dolžino s koraki in med izmerjeno dolžino. Napaka je nastala zaradi tega, ker so učenci napačno izmerili dolžino koraka.

Ker učenci pri poročanju ne znajo izluščiti bistva, smo za to porabili veliko časa, Taka oblika dela učencem omogoča uporabo znanega v novi situaciji in pridobivanje konkretne izkušnje za kasnejše razumevanje abstraktnih pojmov. Učenci so imeli pri pretvarjanju enot manj težav, saj so se naslonili na velikostne predstave, ki so jih pridobili pri praktičnem delu.

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PHYSICS IS MORE INTERESTING IF IT IS RELATED TO TECHNOLOGY
/
POUK FIZIKE JE V POVEZAVI S TEHNIKO BOLJ ZANIMIV

Marija Cehner

OŠ Neznanih talcev Dravograd

marija.cehner1@guest.arnes.si

ABSTRACT

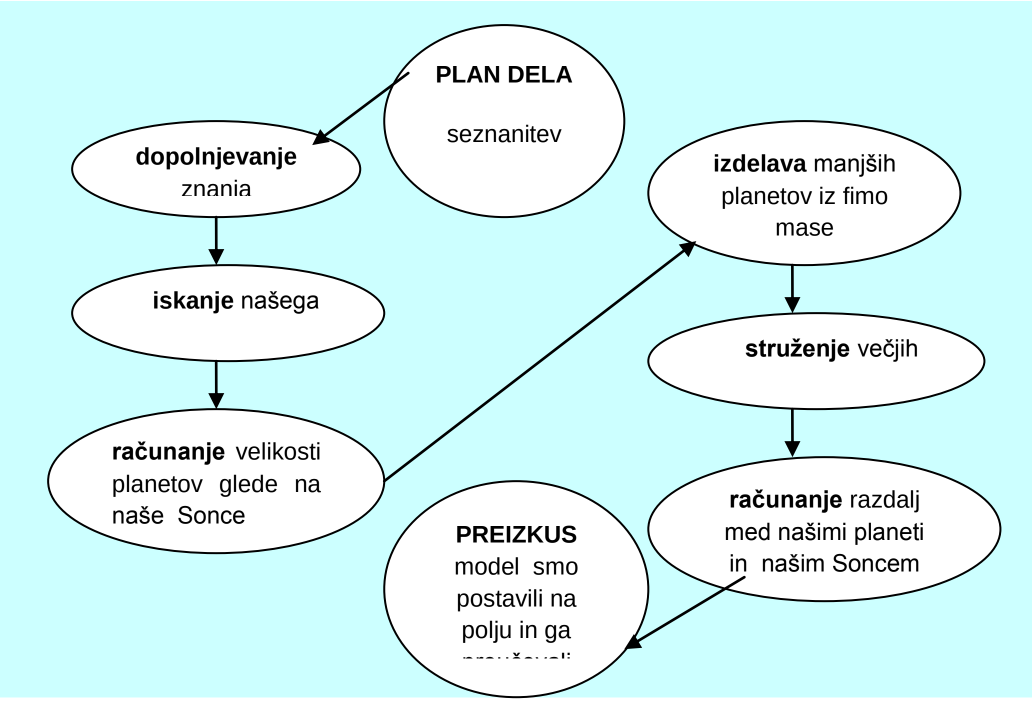
With the students of the subsidiary course of physics we made the model for our Solar system. For the model of the Sun we have used the big gym. For our project we calculated the distances in the measures of the size and the distance of the planets in our solar system. For the small sized planets we used the qualitative mass material, the big planets we made by turning and for the Sun we used a big gym ball. We applied the models of the planets in a natural field to be able to study and examine our project. Other students in the Class of Artificial materials took the challenge and build the car on elastic drive. For construction we searched for the best solution for the drive with two elastic ribbons. As a result of the hard work the two groups of students qualified for the national competition.

Keywords: *The Solar system model, turning, field, car on elastic drive, competition.*

UVOD

Pri poučevanju nenehno iščem poti za izvajanje takega pouka, da so učenci čim bolj aktivni. V projekt so se vključili učenci, ki kažejo večje zanimanje za tehniko in naravoslovje. Pri takih aktivnostih z motivacijo ni problemov. Pri dodatnem pouku v 9. razredu sem učence ob Mednarodnem letu astronomije navdušila za astronomijo in z učenci smo se odločili, da izdelamo model Našega osončja.

METODA



Slika 1: Metoda dela

REZULTATI

Za naše Sonce smo kupili rumeno žogo velikosti 75cm. Manjše planete smo ročno izdelali iz fimo mase, večje planete pa smo stružili iz umetnih snovi v šolski delavnici. Natovorili smo »celoten« sončni sistem, se odpeljali na ravno polje in postavili naš model sončnega sistema v preračunane razdalje ter proučevali, kaj se vidi iz Sonca in iz osmih planetov. Že prej smo si razdelili vloge. Iz mesta Neptuna nismo mogli opazovati planetov in Sonca, saj teren ni bil dovolj horizontalen.

Tabela 1: Izračunani podatki za naš primer velikosti Sonca 75cm.

Planet	Premer (cm)	Oddaljenost od našega Sonca (m)
MERKUR	0.28	32
VENERA	0.68	57
ZEMLJA	0.7	81
MARS	0.35	122
JUPITER	7.7	405
SATURN	6.6	769
URAN	2.6	1134
NEPTUN	2.52	2430

Izdelava elastmobila: V osmem razredu smo pri temi o prožnostni energiji preko spleta pregledali poročilo s tekmovanja o elastomobilih in učenci so sprejeli izziv, da tudi oni izdelajo elastomobil in izmerijo pot, ki jo naredi vozilo s prožnostno energijo navite elastike.

Konstruirali smo razne oblike, iskali rešitve za čim boljši pogon z dvema elastikama.

Vozilo smo izdelali pri izbirnem predmetu obdelava gradiv umetne snovi. Z različnimi konstrukcijami modelov vozil smo dosegli različno dolgo pot in ugotovili, da vozila z navito elastiko dosežejo boljši rezultat kot vozila na napeto elastiko. Pomembna je tudi velikost ter oblika vozila. Trenje med gibljivimi deli mora biti čim manjše, saj so navori majhni. Gibljive dele smo namazali s parafinskim oljem. Naše preizkuse smo primerjali z znanji iz fizike: upor, trenje, prožnostna energija, pretvarjanje energije, navor.

Na šolskem tekmovanju se je pomerilo 13 ekip. Z elastomobilom sta dve naši najboljši ekipi učencev uspešno tekmovali na državnem tekmovanju, saj sta dosegli prvo in tretje mesto.

ZAKLJUČEK

Predstavitev dela učencev na razstavi, intervju na lokalni televiziji ter nagradni obisk fizikov iz Hiše eksperimentov na šoli , kjer so prikazali zanimive poskuse za učitelje, učence in krajane, so bili tudi promocija za fiziko in tehniko.

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DENSITY AND GIFTS IN PHYSICS LESSON
/
GOSTOTA SNOVI IN DARILA PRI FIZIKI

Dušanka Colnar

OŠ Frana Kocbeka Gornji Grad

dusanka.colnar@gmail.com

ABSTRACT

Density is a concept that is easier to grasp if students use their own experience from everyday objects, comparing properties such as mass and volume. The aim of this abstract is to explain how the topic was presented in a double lesson, where students explored blocks that have the same volumes but are of different mass. The main purpose of the research was for students to, explore how different materials with different densities can be analysed to accurately predict which of the known samples could be inside the gift. This was achieved by comparing observations and measurements taken from sample blocks of Iron, Aluminium and Brass.

Keywords: *Research,exploration, density, validation*

UVOD

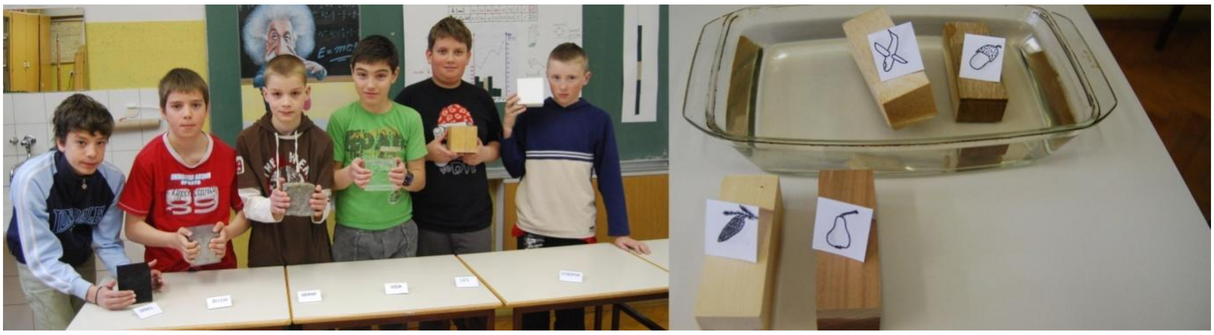
Gostota snovi je ena od fizikalnih količin, ki jih učenci spoznajo pri fiziki v 8. razredu. Učenci pojem gostote lažje osvojijo, če izhajajo iz konkretnih izkušenj, ki jih imajo s predmeti, z njihovimi masami in s prostorninami. Fleksibilni predmetnik nam omogoča različne načine organiziranja pouka. Zato sem lahko pri fiziki v 8. r. izvedla blok uro, ki je sledila učni uri, v kateri so se učenci spoznali s pojmom gostota snovi. Pri načrtovanju blok ure sem želela, da se z gostoto snovi učenci srečajo celostno, zato sem zasledovala tri skupine ciljev. V prvi skupini so bili cilji s področja fizike, v drugi skupini pa cilji s področja matematike. V tretji skupini so bili splošni cilji, ki so se navezovali na način dela, problemski pristop, postavljanje hipotez, raziskovanje, sodelovanje ter na razvijanje veščin in ročnih spretnosti.

METODA

Pouk je potekal v blok uri. Klasičnega frontalnega poučevanja je bilo zelo malo, le v začetku ure pri ponavljanju snovi prejšnje ure in v obliki navodil za delo. Večino časa so se skupine učencev ukvarjale z razreševanjem problema, povezanega z gostoto snovi. Postavili so hipotezo ter jo s pomočjo meritev in izračunov potrdili ali ovrgli. Pri tem so si učenci posamezne skupine delo razdelili, kar pomeni, da so morali med seboj sodelovati in komunicirati. Učenci so bili razdeljeni v sedem skupin. Dve skupini sta določali gostoto medenine, iz katere je izdelana ključavnica obešanka, ostalih pet skupin pa je moralo ugotoviti, v katerem od darilnih papirjev je zavit kvader iz aluminija, železa in medenine.

REZULTATI

Za začetek smo si ogledali 1 dm^3 velike kocke iz stiropora, lesa, vode, granita in železa. Razpravljali smo o njihovih prostorninah in masah ter jih razvrščali glede na gostoto. Vsako od kock so vzeli v roke in marsikateri učenec je bil presenečen, saj je železno kocko težko dvignil. Še bolj jih je, pa tudi vse odrasle, ki smo to preizkusili, dva tedna kasneje presenetila teža kocke, ki je vsebovala 1 dm^3 svinca. Prav tako so se na primerih enako velikih lesenih kvadrov (hrast, hruška, smreka, balsa) prepričali, da nimajo vse drevesne vrste lesa z enako gostoto, zato jih tudi uporabljamo za različne namene. Na spodnji sliki 1 levo vidimo enako velike kocke iz svinca, železa, granita, vode, lesa in stiropora, na sliki 1 desno pa kvadre enakih oblik iz različnih vrst lesa. Ti so za boljšo nazornost fotografirani v vodi.



Slika 1: Fotografija kock iz različnih materialov – levo in fotografija kosov lesa v vodi – desno.

Sledilo je delo v skupinah – trojicah. Dve skupini sta dobili vsaka tri, po velikosti različne ključavnice obešanke, kot je vidno na sliki 2 levo spodaj. Najprej so postavili hipotezo, iz katere snovi so izdelane. Nato so preverjali pravilnost hipoteze. S potapljanjem ključavnic v vodo so izmerili njihove prostornine in s tehtanjem še njihove mase. Gostoto so računali po obrazcu, ki smo ga spoznali prejšnji dan, s pomočjo tabel pa so ugotovili, da so ključavnice izdelane iz medenine. V teh dveh skupinah so bili sposobnejši učenci, ki so rešili še dve računski nalogi. Izračunali so, najmanj koliko cm^3 odpadka bi dobili, če bi iz ključavnice izrezali kvader in koliko % prostornine ključavnice bi predstavljal ta odpadek.

Učenci ostalih skupin so dobili kvadre iz aluminija, železa in medenine, zavite kot darila, kot je vidno na sliki 2 desno spodaj. Razvrščali so jih glede na maso in nato brez merjenja in računanja ugibali, katero od naštetih snovi jim je učiteljica zavila v kateri darilni papir. Sledilo je ugotavljanje pravilnosti postavljenih hipotez. Izmerili so dolžine robov kvadrov in njihove mase ter izračunali gostote. Svoje izračune so primerjali s podatki v tabelah gostot. S tem so potrdili ali ovrgli svojo hipotezo. Pravilnost svojih trditev so preverili še z odvijanjem zavitkov, saj so v njih našli zapisana imena snovi, iz katerih so kvadri. Kvadre so nato pazljivo zavili nazaj v darilni papir in napeljali okrasni trakec.

Slika 2: Fotografija ključavnic – levo in fotografija daril – desno.

Na koncu so poročali o svojih ugotovitvah in komentirali najzanimivejša spoznanja ter napake, ki so jih naredili. Za poročanje so se skupine preoblikovale, tako da je ena poročala o železu, druga o aluminiju in tretja o medenini, četrta je narisala plakat in peta pripravila kratek prispevek za šolsko spletno stran.

ZAKLJUČEK

Učenci so bili obe uri aktivni. Bili so veseli svojih, na podlagi opazovanj oblikovanih sklepov. Težko so postavljali hipoteze, še težje jim je bilo komentirati hipotezo, ki ni bila potrjena kot pravilna. Mislili so, da morajo biti vsa njihova predvidevanja vedno pravilna. Po končani uri so drugim učencem povedali, da neznana snov ni zlato, ampak medenina, in katera od deklic ni mogla dvigniti kocke železa. Nekatera spoznanja so jih presenetila, npr. da so med vrstami lesa takšne razlike in da obstaja lahek les, kot je balsa. Mene pa je presenetilo, da je le peščica učencev prepoznala medenino, da nekateri niso ločili med aluminijem in železom ter da je bilo zavijanje kvadra nazaj v darilni papir za mnoge zelo zahtevno opravilo. Učne ure, kjer bodo učenci pridobivali tako veščine kot druga spoznanja, so nujno potrebne. Z medpredmetnim povezovanjem jih lažje in učinkoviteje izvedemo.

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DOES THE MODEL ASSEMBLY AT CHEMISTRY LESSONS CONTRIBUTE SIGNIFICANTLY TO UNDERSTANDING THOSE GROUPS OF PUPILS WHO ARE LESS SUCCESSFUL LEARNERS?
/
ALI SESTAVLJANJE MODELOV PRI POUKU BISTVENO PRIPOMORE K RAZUMEVANJU TISTIH SKUPIN UČENCEV, KI SO SICER MANJ UČNO USPEŠNI?

Matejka Černe

OŠ Solkan

matejka.cerne@guest.arnes.si

ABSTRACT

The research was conducted in three classes of the 9th grade primary school using / employing three different teaching approaches. In the first class pupils learnt in groups using the models; in the second class the teacher conducted the lesson frontally without the use of the models; and in the third class the combination of frontal teaching and ICT (computer animations) was employed. Although the results of the examinations (written tests and oral examinations) did not show significant differences in the knowledge of most pupils with average and above average grades at chemistry, the assembly models proved helpful for those pupils who are less successful (i.e. have on average lower grades). The use of models is essential in the implementation of differentiation (individualization) in classes where pupils need to be offered different teaching aids.

Keywords: *use of models for learning chemistry, understanding chemistry, quality of knowledge.*

UVOD

Za uspešno učenje kemije v osnovni šoli in boljšo kakovost znanja se pri ponazarjanju prostorske zgradbe snovi ali kemijskih reakcij pri pouku kemije posebno priporoča uporaba vizualizacijskih elementov, kot so modeli atomov in molekul ter računalniške animacije. Ti elementi imajo ključno vlogo pri razumevanju naravoslovnih pojmov in zakonitosti submikroskopskega sveta, saj omogočajo postopen prehod od makro ravni preko submikro do simbolne ravni.

METODA

Prvotni namen raziskave je bil ugotoviti, kolikšna je razlika v znanju učencev, ki so se učili z modeli in učenci, ki so se učili brez modelov.

Raziskava je potekala z učenci 9. razredov pri obravnavi vsebinskega sklopa kisikove organske spojine (zgradba kisikovih organskih spojin in reakcije nastanka kisikovih organskih spojin). Učenje je potekalo vzporedno v treh oddelkih s tremi različnimi didaktičnimi pristopi. V prvem oddelku so se učenci učili v skupinah z uporabo modelov (v nadaljevanju oddelek »modeli«), v drugem oddelku je potekal pouk frontalno z učiteljevo razlago in brez uporabe modelov (v nadaljevanju oddelek »frontalna«), v tretjem pa s kombinacijo frontalnega pouka z učiteljevo razlago ob uporabi modelov in uporabo IKT (v nadaljevanju skupina »frontalna +IKT«).

Oddelek »modeli« so imeli ves čas obravnave na voljo modele. In sicer vsaka skupina 1kpl, pri utrjevanju pa učenci z oceno zadostno pri kemiji, individualno vsak svoj komplet modelov.

Oddelek »frontalna« je obravnavo imel popolnoma brez modelov, skupina frontalna + IKT pa je modele sestavljala samo učiteljica demonstrativno, pri uporabi IKT pa je vsak učenec imel na voljo svoj računalnik in v svojem tempu reševal naloge testov na spletni strani Keminfa z naslovom »Uporaba molekulskih modelov pri poučevanju in učenju kemije« © NTF-KII, verzija 2008 ter Kemijski vizualizacijski test (Ferk; 2000).

REZULTATI

Rezultati preverjanj, tako pisnih kot ustnih niso pokazali bistvenih razlik v znanju učno uspešnejših učencev, ne glede na didaktični pristop pri obravnavi ciljev.

Razlika v razumevanju se je pokazala pri učno manj uspešnih učencih. Učenci, ki so imeli možnost sestavljati modele, so se bolje izkazali pri reševanju nalog, ki so vključevale slike modelov spojin, od učencev, ki modelov niso imeli možnost sestavljati. Pri ustnem ocenjevanju je bilo vsem učencem v vseh treh oddelkih ponujeno, da lahko uporabijo modele. To možnosti so izkoristili učno manj uspešni učenci iz oddelka, ki je usvajal kisikove organske spojine ob sestavljanju modelov. Ti učenci so z uporabo modelov naloge uspešno rešili in dobili boljšo oceno kot je sicer njihova povprečna ustna ocena pri kemiji. Učenci tega oddelka, ki dosegajo povprečne in nadpovprečne rezultate (ocene) pri pouku kemije, so brez težav rešili naloge pri ustnem ocenjevanju brez uporabe modelov. Prav tako so le redki učenci iz ostalih dveh oddelkov, ki niso samostojno sestavljali modelov ob obravnavi snovi, posegli po ponujenih modelih pri ustnem ocenjevanju.

ZAKLJUČEK

Učencem je potrebno ponuditi v procesu učenja različne učne pristope in različne učne pripomočke. Med pomembne vizualizacijske pripomočke zagotovo sodijo modeli vseh vrst in računalniške animacije. Z raziskavo sem ugotovila, da je sestavljanje modelov pri pouku kemije velikega pomena predvsem za tiste učence, ki so sicer učno manj uspešni. Samostojna uporaba modelov vpliva na boljšo predstavnost in razumevanje, spodbuja učenčevo aktivnost in podaljša čas zbranosti.

V nadaljevanju raziskave bi bilo smiselno ponovno preveriti znanje učencev in preveriti morebitne razlike v kakovosti in trajnosti znanja učencev čez določeno časovno obdobje.

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ASSESMENT OF GENE TECHNOLOGY ACCEPTABILITY AMONG SECONDARY SCHOOL STUDENTS
/
UGOTAVLJANJE SPREJEMLJIVOSTI GENSKE TEHNOLOGIJE MED DIJAKI

Helena Črne Hladnik

Gimnazija Šiška

helena.hladnik@gmail.com

Katarina Košmelj

Univerza v Ljubljani, Biotehniška fakulteta

katarina.kosmelj@bf.uni-lj.si

Branka Javornik

Univerza v Ljubljani, Biotehniška fakulteta

branka.javornik@bf.uni-lj.si

Cirila Peklaj

Univerza v Ljubljani, Filozofska fakulteta

cirila.peklaj@ff.uni-lj.si

Aleš Hladnik

Univerza v Ljubljani, Naravoslovnotehniška fakulteta

ales.hladnik@ntf.uni-lj.si

ABSTRACT

We live in a time characterized, among other things, by rapid advances in gene technology, genomics and biotechnology. These disciplines have undoubtedly brought many benefits to our lives but they also raise numerous ethical, environmental and social questions. Not much research has been done so far in Slovenia systematically to explore public perception towards biotechnological issues. In particular, little is known about the attitudes of young generations that will be mostly affected by this technology in the future. To fill this gap, a comprehensive survey was conducted in the 2006/07 school year among 16 to 17 year old high school students. Altogether, 469 students from different Slovenian regions participated in the study. We wanted to examine how students assess four selected biotechnological examples: Bt corn, genetically modified salmon, somatic- and germ-line gene therapy.

Keywords: *biotechnology, usefulness, moral acceptability, risk, high students, attitudes*

UVOD

V Sloveniji do sedaj ni bilo izvedenih prav veliko raziskav, ki bi preučevale stališča širše javnosti do biotehnoloških vsebin. Sploh pa ne med mladimi, na katere bo imela omenjena tehnologija nedvomno največji vpliv. Da bi zapolnili vrzel tovrstnega preučevanja med mladostniki, starimi med 16 in 17 let, smo v šolskem letu 2006/07 opravili raziskavo, v kateri je sodelovalo 469 dijakov oziroma 8,4% vseh slovenskih tretješolcev gimnazijskega programa z osrednjeslovenske (ljubljanske), gorenjske, notranjske, štajerske in dolenjske regije. Zanimalo nas je, kako posamezni dejavniki kot so znanje in razumevanje molekularne in človeške genetike, spol dijakov, teža etične dileme, področje genske tehnologije in vrsta organizma, ki ga gensko spreminjamo, vplivajo na presojanje genske tehnologije z vidika uporabnosti, etično moralnega vidika in stopnje tveganosti.

METODA

Ker do leta 2008/09 učni načrt za biologijo za tretješolce ni vključeval biotehnoloških vsebin, smo jim le-te na kratko predstavili v obliki predavanja, podprtega z elektronskimi prosojnicami, in kratkim odlomkom iz dokumentarnega filma. V raziskavo smo vključili štiri biotehnološke primere s področja kmetijstva in medicine: gensko spremenjeno Bt koruzo, gensko spremenjene (GS) losose ter somatsko in zarodno gensko zdravljenje (GZ) hemofilije. Potrebno je poudariti, da so bili izbrani biotehnološki primeri dijakom predstavljeni tako, da so bile izpostavljene tako njihove prednosti kot tudi morebitna tveganja na račun zdravja potrošnikov in posegov v organizme oz. širše okolje ter etični pomisleki. Dijaki so presojali sprejemljivost vsakega od omenjenih primerov z vidika uporabnosti, etične sprejemljivosti in tveganosti s pomočjo petstopenjske lestvice strinjanja "nikakor ne – malo – srednje – precej – popolnoma". Pri vsakem vprašanju pa so napisali še utemeljitev svojega mnenja.

REZULTATI

Na podlagi rešenih vprašalnikov smo izdelali kvantitativno in kvalitativno analizo. Ugotovili smo, da so dijaki presojali Bt koruzo kot najbolj uporabno in najmanj tvegano. Kvalitativna analiza je pokazala, da so dijaki relativno visoko ocenili uporabnost Bt koruze na račun večjega pridelka in manjše škode za okolje v primerjavi z uporabo pesticidov. Ocene uporabnosti in moralne sprejemljivosti Bt koruze so bile zelo podobne ocenam somatskega GZ, GS losose in zarodno GZ pa so dijaki vrednotili podobno vendar z bistveno nižjimi ocenami od prej omenjenih aplikacij. Na podlagi kvalitativne analize smo ugotovili, da imajo dijaki bistveno več etičnih zadržkov v zvezi z zarodnim kot somatskim GZ. Med utemeljitvami so izpostavljali, da se jim ne zdi moralno sprejemljivo, da starši odločajo o usodi svojih potomcev. Statistično značilne razlike po spolu smo ugotovili v primeru zarodnega GZ in GS lososov. Dekleta so v primerjavi s fanti nižje ocenila uporabnost zarodnega GZ in GS lososov. Dekletom se je zdelo gensko spreminjanje lososov etično manj sprejemljivo kot fantom. Prav tako so dekleta v primerjavi s fanti zaznavala večjo tveganost v zvezi z zarodnim in somatskim GZ. Ugotovili smo, da je pri dekletih znanje molekularne in človeške genetike imelo večji vpliv na presojanje biotehnoloških primerov kot pri fantih. S kvalitativno analizo stališč dijakov v zvezi z etično-moralnim presojanjem smo v vseh štirih primerih zasledili pojavljanje tako vzorcev racionalističnega (deontološko in teleološko) kot tudi intuitivnega utemeljevanja. Le v primeru GS lososov se je pojavil tudi vzorec čustvenega utemeljevanja. Naša raziskava je potrdila povezavo med težavnostjo etične dileme, kot so jo zaznali strokovnjaki in uporabnostjo biotehnoloških primerov, ki so jo ocenjevali dijaki. Primera zarodnega GZ in GS lososov, ki so ju strokovnjaki ocenili kot etično najbolj težavna, so dijaki presojali kot najmanj uporabna. Po drugi strani pa so dijaki somatsko GZ in Bt koruzo ocenili kot najbolj uporabno, strokovnjaki pa kot etično manj težavna primera.

ZAKLJUČEK

Po odzivnosti dijakov med samo študijo lahko sklepamo, da so bili dokaj motivirani za razpravljanje o biotehnoloških primerih. Upamo, da bo naša raziskava spodbudila vključevanje družbeno naravoslovnih tem v šolsko prakso, saj to zagotovo lahko vodi do boljšega promoviranja naravoslovne pismenosti. Poleg tega pa naj bi omenjene tematike spodbujale tako intelektualni kot tudi moralni in socialni razvoj učencev.

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CROSS-CURRICULAR CONNECTION OF MATHEMATICS, DESING AND TECHNOLOGY, SCIENCE, AND ART AND DESING
/
MEDPREDMETNO POVEZOVANJE MATEMATIKE, TEHNIKE IN TEHNOLOGIJE, NARAVOSLOVJA IN LIKOVNE VZGOJE

Karmen Debenjak

OŠ Ivana Roba Šempeter pri Gorici

karmen.debenjak@gmail.com

ABSTRACT

Geometry is an inexhaustible source of mathematical notions and ideas. It is an ideal field for cross-curricular connection and search for similarities in everyday life. This paper presents the work in the 8th grade on the topic of polygons. The stress is on group work, classification and argumentation. The pupils presented their ideas and made a final report. While working, they integrated knowledge from various fields into one whole. In order to make a polygon, one has to use spatial perception, accuracy, persistence and orderliness. These skills can be gained during Mathematics, Design and Technology and Art and Design classes.

Keywords: *polygons, cross-curricular connection*

UVOD

Geometrija je neizčrpen vir matematičnih pojmov in idej, idealno področje za medpredmetno povezovanje ter za iskanje podobnosti v vsakdanjem življenju. Eden glavnih ciljev učitelja je učencem pomagati razviti njihovo zmožnost, da uporabljajo matematično znanje pri reševanju problemov. Želja učitelja je tudi, da bi učenci pridobili pozitiven odnos do matematike, da se je ne bi bali ter da bi z večjim veseljem reševali nove probleme.

Kitajska modrost pravi: kar sem slišal, sem pozabil; kar sem videl, sem si zapomnil; kar sem delal, sem se naučil. Zato je treba učence spodbuditi k ustvarjalnemu razmišljanju, raziskovanju, predvsem pa k samostojnemu odkrivanju znanja. Probleme, ki jim zastavimo, naj bi znali analizirati in oblikovati ustrezne ugotovitve.

METODA

V prispevku bom predstavila delo v 8. razredu v okviru ur aktivnosti na temo Večkotniki. Pri teh urah učenci s svojim matematičnim in drugim znanjem kompleksno obdelajo matematične ali ne matematične vsebine. Pri tem je poudarek na delu v skupini (dogovarjanje, razdelitev dela, koordinacija, komuniciranje), na klasificiranju in utemeljevanju, nadalje na predstavitvi svojih zamisli in na izdelavi poročila. Ob izvajanju dejavnosti učenci povezujejo znanja različnih področij v celoto.

V skupinah so s pomočjo različnega materiala ugotavljali, kaj so večkotniki in kje jih dobimo v vsakdanjem življenju.





Slike 1- 5: Večkotniki, ki jih uporabljamo v vsakdanjem življenju

S pomočjo Geo plošče so spoznali vrste večkotnikov in njihove lastnosti. S preiskovanjem (risanje, rezanje, lepljenje, sistematično zapisovanje ugotovitev ...) so raziskali diagonale, središčni kot, vsoto notranjih in zunanjih kotov.

S pomočjo slik in fotografij različnih rastlin in živali ter drugih sestavin iz narave so ponovili simetrije, ki so jih obdelali v 7. razredu. Na vsaki sliki so narisali vse simetrije, jih poimenovali in ponovili njihove lastnosti. Pri biologiji so rastline in živali razvrščali v sisteme.

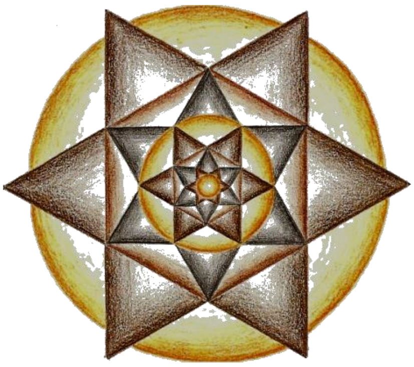



Slika 6 - 9: Simetrije v naravi

Spoznali so pravilne večkotnike, njihove lastnosti ter načrtovanje. Konstruiranje večkotnikov zahteva od posameznika uporabo prostorske predstave, veliko natančnosti, vztrajnosti pa tudi urejenosti. Te spretnosti lahko z vajo pridobivajo tako pri matematiki, tehniki in tehnologiji in likovni vzgoji.

REZULTATI

Učenci so s pomočjo preprostega raziskovanja spoznali celotno poglavje Večkotniki, s pomočjo slik in fotografij iz narave so ponovili in utrdili simetrije in z njihovo pomočjo načrtovali pravilne večkotnike. Pri tem so nastali številni izdelki, ki so jih še likovno opremili. Sledila je razstava in izdelava voščilnic z vzorci večkotnikov.



Slika 10: Izdelek učenke

ZAKLJUČEK

Tak način dela zahteva od učitelja drugačno in časovno obsežnejšo pripravo zaradi iskanja različnega gradiva. Predvsem pa mora paziti, da ne ostane samo na površnem prikazovanju matematike. Pri samem usvajanju snovi je koordinator in voditelj, učenci so glavni akterji, zato so zelo motivirani za delo, ki od njih zahteva veliko medsebojnega sodelovanja, aktivnega dela, povezovanja različnih znanj pa tudi individualno in samostojno delo. Učenci so bili navdušeni nad izdelki, ki so nastali z načrtovanjem različnih večkotnikov. Te ure so bile izpeljane v prednovoletnem času, ki je zelo primeren za izvajanje takih dejavnosti.

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HOW TO MAKE TECHNOLOGY INTERESTING TO PUPILS?
/
KAKO PRI OSNOVNOŠOLCIH VZBUDITI ZANIMANJE ZA TEHNIKO?

Ivan Dović

OŠ Brinje Grosuplje

ivo.dovic@gmail.com

ABSTRACT

In this presentation I will talk about my idea of making technology interesting to pupils aged between 11 and 14. During my lessons I encourage pupils to gain knowledge through their own experience; therefore I always organize work according to the project learning method. I make sure that projects are interesting and entertaining to pupils and I try to include the largest possible number of aims, determined by the national curriculum. Such working method has proved to be successful- in school year 2009/2010 approximately 20% of pupils applied for model making class as one of extra-curricular activities at our school and 25% of pupils in the Years 7, 8 and 9 decided to take elective technology subjects. I will present two projects realised during the lessons of Design and Technology in Year 7 and model making class.

Keywords: *project learning method, curriculum, aims, electric car, eco speed boat, plastic, composite materials, fibreglass, electric motor.*

UVOD

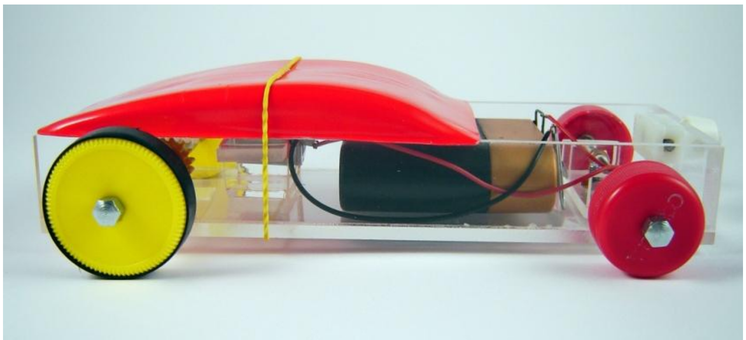
V prispevku bom predstavil izdelek, ki ga v 7. razredu osnovne šole izdelujemo pri predmetu Tehnika in tehnologija. Izdelek je zasnovan tako, da se ob njegovi izdelavi učenci srečajo s čim več vsebinami predpisanimi z učnim načrtom in preko lastne izkušnje usvajajo učne cilje. V nadaljevanju pa bom opisal primer projektnega dela pri interesni dejavnosti (modelarskem krožku). Z učenci smo zasnovali in izdelali 3,5 metra dolg gliser z električnim pogonom.

METODA

Izdelava električnega avtomobilčka iz umetne mase

Električni avtomobilček (Slika 1) sem zasnoval na podlagi učnih ciljev in vsebin, ki prevladujejo v tem razredu. To so umetne mase, elektrika, mehanizmi za prenos gibanj, računalniško krmiljenje in pravokotna projekcija oz. tehnično risanje. Karoserija avtomobilčka je izdelana iz umetnih mas. Med njeno izdelavo učenci spoznajo osnovne obdelovalne postopke umetnih mas kot so žaganje, brušenje, vrtanje, pa tudi nekoliko bolj zahtevne kot so termično preoblikovanje in globoki vlek. Avtomobilček poganja električni motor, ki ga morajo učenci pravilno zvezati v sklenjen električni krog s stikalom in virom el. napetosti. Izdelati morajo prenos gibanja od motorja na pogonski kolesi, kar storijo s polžastim in valjastim zobnikom. Tehnično dokumentacijo izdelamo s pomočjo računalnika. Avtomobilček je izdelek, katerega izdelava skoraj v celoti pokrije cilje in vsebine določene z učnim načrtom.

Na koncu leta med glavnim odmorom v šolski avli obvezno priredimo še zabavno tekmovanje avtomobilčkov.



Slika 1: Električni avtomobilček

Izdelava 3,5 metra dolgega električnega gliserja na modelarskem krožku

V devetih letih mojega poučevanja smo na šoli vzpostavili tradicijo nekoliko večjih projektov, ki se jih lotevamo na modelarskem krožku. Po uspešni izdelavi trimetrske jadrnice, dvo in pol metrskega Space Shutlla in pravega električnega avtomobila, smo kot zadnjega po dveh letih dela dokončali tri in pol metrski gliser z električnim pogonom (Slika 2). Idejo za njegovo izdelavo so dali učenci, saj so se v prejšnjih letih v šolski jadrnici naveličali čakati na ugoden veter. Skupaj smo poiskali način gradnje gliserja, ki bi mu bili kos tudi osnovnošolci in ki bi prinesel otipljive rezultate v relativno kratkem času, ki smo ga imeli na voljo. Odločili smo se za izdelavo gliserja iz vezane plošče oblečenega v poliestrsko smolo in stekleno tkanino. Med njegovo izdelavo so učenci spoznali veliko novih obdelovalnih postopkov lesa (delo z električno vbodno žago, električnim obličem, upogibanje vlažnega lesa….), delo s kompozitnimi materiali (poliestrska smola in steklena tkanina), obdelave kovin (delo na stružnici za kovine), vgradnja mehanskih sklopov (pogonska gred motorja, krmilni mehanizem…), vgradnja in vezava elektromotorja z elektronskim krmilnikom vrtljajev…

REZULTATI

Ob izdelavi električnega avtomobilčka učenci v sproščenem vzdušju usvajajo zastavljene cilje. Avtomobilček so učenci zelo dobro sprejeli in ga z veseljem izdelujejo ter izboljšujejo tudi v prostem času. Med izdelavo gliserja smo se ogromno naučili tako učenci kot tudi jaz. Vsi smo bili zelo visoko motivirani za delo, v delavnici smo ostajali po pouku, in v šolo prihajali tudi med počitnicami. Za svoje delo smo bili nagrajeni z uspešno javno splovitvijo in z zlatim priznanjem na tekmovanju mladih tehnikov.

Slika 2: Gliser z električnim pogonom

ZAKLJUČEK

Rezultat metode dela, ki upam da ja razvidna iz tega kratkega prispevka, je izjemno zanimanje otrok za tehniko na naši ne ravno veliki šoli. To se lepo vidi pri modelarskem krožku, ki ga v dveh skupinah obiskuje skoraj 40 otrok in pri izbirnih predmetih. S področja tehnike smo letos imeli štiri izbirne premete, ki jih je obiskovalo preko 60 otrok. Menim, da v danih razmerah poslanstvo osnovnošolskega učitelja ni zgolj v tem, da učencem posreduje določena znanja, ki so v današnjem času pogosto že zastarela, pač pa v tem, da učencem omogoči, da se preko lastne izkušnje srečajo s številnimi področji znotraj tehnike in tehnologije in jih poizkusi navdušiti za katero izmed njih. V kolikor učitelju to uspe, mora biti sposoben učenca usmerjati v iskanje nadaljnjih informacij in znanj s tega področja in zaupati, da bo učenec, ki ga zanima določeno področje s časoma to znanje tudi osvojil in ga nadgradil.

Več fotografij o električnem avtomobilu in EKO gliserju ter informacij o mojem delu nasploh je na voljo na spletnem naslovu: http://www2.arnes.si/~idovic

REFERENCE

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DEVELOPMENT PROJECT ENERGY AS A VALUE
/
RAZVOJNI PROJEKT ENERGIJA KOT VREDNOTA

Matej Forjan

Šolski center Novo mesto

matej.forjan@siol.net

Ivica Tomić

Šolski center Novo mesto

ivica.tomic@guest.arnes.si

Matej Rožič

Šolski center Novo mesto

rozicmatej@gmail.com

ABSTRACT

Changes in our environment and society require a well-educated scientists who know how to take meaningful decisions about it. Therefore, we at Šolski center Novo mesto set an ambitious four-year project Energy as a value, whose aim is to enhance students' science literacy. In the first part of the project, 93 students in the first year explored and analyzed domestic consumption of electricity and find opportunities for more rational use of energy. Each student has created a 30-40 pages project report, which is detailed and systematically presents their research findings.

Keywords: *domestic energy consumption, project work*

UVOD

Človeštvo se v 21. stoletju razvija hitreje kot kdajkoli prej in izzivi, katere prihodnost prinaša, se ne dotikajo le strokovnjakov, ampak tudi navadnih ljudi in njihovih življenjskih situacij. Ti izzivi so povezani s čedalje večjo globalizacijo, hitrim tehnološkim razvojem in posledičnimi zahtevami za kompetencami, kot so kreativnost, fleksibilnost, sposobnost za timsko delo in kompetence na področju IKT. Med omenjene izzive sodijo globalno segrevanje, trajnostni razvoj ter smotrno ravnanje z energijo in energetskimi viri. Naloga pouka fizike in naravoslovnih ved nasploh je, da dijake nauči naravoslovne pismenosti. Biti naravoslovno pismen ne pomeni le, da poznamo osnovne koncepte, zakone in metode naravoslovja, ampak pomeni tudi, da smo sposobni to znanje združiti z znanji z drugih področij, ga združiti z osebnimi prepričanji in vrednotami ter ga uporabiti v vsakdanjem življenju. Le naravoslovno pismen človek ve, kako se argumentirano odločati v primerih, ki zadevajo naravoslovje, kot so na primer energijska poraba, okoljevarstvena politika, globalno segrevanje ali genetski inženiring.

Projekt *Energija kot vrednota* je na Srednji elektro šoli in tehniški gimnaziji na Šolskem centru Novo mesto zastavljen kot razvojni projekt, pri katerem se učitelji usposabljajo za timsko, sodelovalno in interdisciplinarno poučevanje, pri dijakih se pa krepi naravoslovna pismenost in se jim tako ponudi čvrsta podlaga za individualno odgovorno in globalno solidarno življenje*.*

Energija kot vrednota je štiriletni projekt, pri čemer v vsakem letniku izvedemo en sklop. Prvi sklop, ki smo ga izvedli v šolskem letu 2008/2009, je imel naslov *Racionalna raba energije doma* in v njem so sodelovali dijaki treh oddelkov prvega letnika tehniške gimnazije, to je 93 dijakov. V šolskem letu 2009/2010 izvajamo sklop *Energijske spremembe*, v šolskem letu

2010/2011 bomo nadaljevali s sklopom *Zmanjševanje porabe in povečanje energetske učinkovitosti*, štiriletni projekt pa bomo zaključili s sklopom *Globalna energetska prihodnost*.

Primarna naloga prvega sklopa *Racionalna raba energije doma* je bila priprava aktivnosti, pri katerih bi dijaki ugotavljali pomen učinkovitega in racionalnega gospodarjenja z energijo. V ta namen je 14 učiteljev sodelujočih predmetov v projektu – fizike, matematike, informatike, slovenščine in tujega jezika – izdelalo skupen načrt izpeljave teh aktivnosti, pri čemer so celotno delo koordinirali in vodili učitelji fizike, ki je bila temeljni predmet, ostali predmeti pa so odigrali vlogo podpornih predmetov.

METODA

Glavni del sklopa je bilo raziskovalno delo dijakov o porabi električne energije pri njih doma. Tako so od novembra 2008 do marca 2009 dvakrat dnevno beležili porabo električne energije v svojih gospodinjstvih. Na podlagi dobljenih rezultatov so dijaki izdelali obsežno poročilo, ki je zajemalo od 30 do 40 strani in v katerem so natančno predstavili porabo električne energije v njihovem gospodinjstvu ter podali smernice za bolj smotrno izrabljanje energije. V prvem delu naloge so dijaki spremljali dnevna, tedenska ter mesečna nihanja porabe električne energije in iskali vzroke za ta nihanja. Poleg tega so za vsak teden natančno analizirali porabo električne energije na družinskega člana ter porabo na vsak kvadratni meter uporabne površine. Vse meritve in izračune so ustrezno predstavili v obliki tabel in grafikonov. V drugem delu naloge so analizirali, koliko električne energije mesečno porabi posamezen električni porabnik v hiši ter dobljene podatke sistematično predstavili v tabelarični obliki.

Ker smo želeli dobiti povratne informacije o izvedbi projekta, so v poročilih bila dodana tudi mnenja in predlogi dijakov in staršev. Po analizi zapisanih mnenj smo ugotovili, da si tako dijaki kot tudi starši kljub obsežnosti izvedene raziskave želijo več takih projektov, ki ne le, da pri dijakih razvijajo kompetence, potrebne za njihovo nadaljnje izobraževanje in življenje, ampak tudi pokažejo, na katerih področjih lahko posamezna družina racionalizira porabo energije in s tem doda svoj kamenček v mozaik bolj učinkovitega ravnanja z energijo. Izdelana poročila smo učitelji pregledali in na podlagi doseženih ciljev, katere smo s projektom želeli doseči, pri vključenih predmetih dijake tudi ocenili.

REZULTATI

Glavni rezultat prvega sklopa predstavlja 93 poročil posameznih dijakov, v katerih so natančno opisali postopek dela na projektu ter sistematično in pregledno predstavili vse svoje ugotovitve v zvezi z porabo električne energije v njihovim domovih. Obvezni del vsakega poročila predstavljajo tudi mnenja dijakov in staršev o projektu ter vpliv ugotovitev projekta na racionalnejšo porabo električne energije.

V vsakem od treh sodelujočih razredov so dijaki iz posameznih poročil naredili tri skupna poročila, ki so obravnavala tri različne tipe bivališč – stanovanja, mestne hiše in hiše na podeželju. Na ta način smo dobili še natančnejše informacije o rabi električne energije, obenem pa so dijaki spoznavali tudi prednosti in zahteve timskega dela.

ZAKLJUČEK

Pozitivne izkušnje iz prvega sklopa projekta kažejo, da smo na pravi poti in da je projekt smiselno nastavljen, saj dijakom poleg razvoja ustreznih kompetenc omogoča, da svoja razmišljanja in ugotovitve o pridobivanju, uporabi in varčevanju energije dijake raznesejo tudi v svoje domove in širše življenjske skupnosti.

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TEACHING SCIENCE IN ENGLISH
/
POUČEVANJE NARAVOSLOVJA V ANGLEŠČINI

Nataša Glodež

OŠ Voličina

natasa.glodez@guest.arnes.si

ABSTRACT

The article presents cross curricular activities from the area of teaching English through the subject of Science. English teachers teach Science and technology topics from the fourth grade where pupils learn simple vocabulary, whereas in higher grades they would develop skills like analysis, synthesis, and evaluation over the following topics: animal and plant world, inventions, environmental issues, findings in science and technology. To motivate pupils into doing research in science and technology, working on an international project like Comenius is a very good idea. Comenius helps teachers and students to step out of the classroom and demands from the teachers to be flexible, cooperative, and ready to learn new things. Our Comenius-school partnership is a science-language project. Humanistic and inquiry-oriented science teaching is a teaching method that engages students in solving problems in science as an integral part of learning English.

Keywords: *international projects, cross curricular activities, Comenius-school partnership.*

UVOD

Učenci že v času osnovnošolskega izobraževanja pričnejo prevzemati odgovornost za samostojno delo in manjšo odvisnost od učitelja. Zavedajo se, da je uspeh povezan s številnimi nejezikovnimi znanji in uspešnimi strategijami za samostojno učenje. Učence pripravljamo na vseživljenjsko učenje s pomočjo različnih vsebin in dejavnosti, za to pa so nujne medpredmetne povezave. Sam angleški jezik je sredstvo za navezovanje medosebnih odnosov in jezikovnih stikov v tujem svetu. Pomembno je, da je vsebinsko in težavnostno povezan z učenčevim spoznavnim razvojem. Tako se na primer tema 'Naravoslovje in tehnika' pojavlja od četrtega do devetega razreda, pri čemer gre v četrtem razredu za poimenovanje besedišča in tvorjenje preprostih povedi (kaj jim je všeč, kaj jim ni všeč), v višjih razredih pa razvijajo višje spoznavne sposobnosti: analizo, sintezo, vrednotenje, presojanje preko tem, kot so rastlinski in živalski svet, odkritja in izumi, neživa narava, skrb za okolje, dognanja v znanosti in tehniki.

Veliko motivacijsko prednost in medpredmetno povezovanje predstavljajo projekti, v katere se šole vključujejo. Od učiteljev se pričakuje fleksibilnost, pripravljenost na učenje, sodelovanje in timsko delo. Učitelji družboslovnih predmetov smo velikokrat v zadregi, kadar gre za projekte z naravoslovno ali tehniško vsebino. Ker velikokrat čutimo premalo usposobljenosti za sodelovanje, je pomembno, da pristopimo iz drugega zornega kota in razmislimo, kako lahko naravoslovne in tehniške vsebine vključimo v predmet, ki ga poučujemo. Pri tem je nujno potrebno poznavanje ciljev učnega načrta, na podlagi katerega pripravimo letno pripravo, ki zajema cilje posameznega projekta z naravoslovno in tehniško vsebino.

Projekt Comenius omogoča izstopiti iz konteksta učilnice. Poleg naravoslovnih vsebin učenci izboljšujejo znanje angleškega jezika, izvajajo medsebojno načrtovan naravoslovni raziskovalni projekt, organizirajo svoje delo in predstavijo rezultate. Projekt predstavlja tudi vprašanje jezikov v naravoslovju. Združevanje poučevanja jezikov in naravoslovja je zelo pogosto, vključevanje jezikovnih dejavnosti v poučevanje naravoslovja pa je za otroke tudi privlačnejše in spodbudnejše. Tak način poučevanja naravoslovja v povezavi s tujim jezikom bolje odraža izkušnjo naravoslovnih raziskovalcev kot sam pouk naravoslovja. Na OŠ Voličina smo sodelovali v raziskovalnem naravoslovno-jezikovnem projektu 'Kako rentgenski žarki vplivajo na rastlinsko rast'. Vsebinski del projekta je pripravil profesor iz Finske, ki je pripravil mapo s teoretičnim uvodom, navodili za delo in tabelami za vpisovanje rezultatov.

METODA

Delo v Comeniusu je zastavljeno projektno in od učiteljev zahteva veliko motivacije in predvsem želje po spoznavanju novega, zahtevnega in drugačnega. Lahko se preizkusijo v ustvarjanju idej in nove, dodane vrednosti, bogatejši so za nova strokovna in druga spoznanja ter za povsem življenjske izkušnje, ki jim jih ne more nihče več odtujiti. Potrebno je tudi ustrezno motivirati učence.

Metode, ki smo jih na naši šoli uporabili pri projektu: raziskovalno delo, neposredno opazovanje, praktično delo, delo z besedilom, samostojno delo. Učenci so urili spretnosti sklepanja, primerjanja, povzemanja in diskusije. Uporabili smo obliko dela v dvojicah. Uporabili smo semena redkvic, ki so bila izpostavljena različnim jakostim rentgenskih žarkov: 50Mrad, 150Mrad in 500Mrad. Rast smo primerjali s kontrolno skupino, ki žarkom ni bila izpostavljena. Potek dela: učenci so v dvojicah prebrali teoretični uvod, da bi se spoznali z vsebino in načinom dela. Seznanili so se z neznanim strokovnim besediščem. Neznane besede so samostojno poiskali v angleškem slovarju in se pogovarjali o pomenu posamezne besede. Sledil je razgovor v angleščini in učenci so na podlagi svojega že usvojenega znanja iz naravoslovja sklepali, kakšni bi lahko bili raziskovalni rezultati. Dogovorili smo se, kdaj bomo semena posadili, dvojice pa so pripravile seznam pripomočkov, ki jih morajo prinesti od doma (4 plastične lončke s podstavki, zemljo, alkoholni flomaster). Pred sajenjem so učenci izmerili pH zemlje, napolnili plastične lončke in v vsak lonček posadili 4 semena redkvic (vsako seme posebej in ne preveč globoko v zemljo) ter zalili. Na lončke so označili, kaj so posadili. Sledilo je 22 dnevno opazovanje rasti, beleženje rezultatov, primerjava rezultatov in dnevna diskusija o poteku. Na skupnem srečanju vseh držav partneric so učenci svoje rezultate predstavili in oblikovali skupno poročilo, ki je vsebovalo rezultate vseh sodelujočih.

REZULTATI

Rezultati so vsebovali beleženje števila vzklitja, velikost, število listov, umrljivost. Učencem je beleženje rezultatov vzelo petnajst minut dela na dan. Raziskovalni rezultati so pokazali razliko v rasti redkvic, izpostavljenim različnim jakostim rentgenskim žarkom. Najmanj izpostavljene se zrasle najvišje, največ izpostavljene pa so umrle. Učenci so razvijali svoje spretnosti na motivacijskem področju, kognitivnem in socialnem področju. Poleg vsebinskih raziskovalnih rezultatov smo ugotovili, da se je med učenci zelo povečalo sodelovanje, samostojnost, komunikacija in tekočnost angleščine z uporabo novega strokovnega besedišča. To smo ugotovili s preprosto metodo intervjuja. Izboljšale so se spretnosti analize, sinteze, abstrahiranja in diskusije. Izboljšanje teh spretnosti so ugotovili tudi drugi učitelji pri pouku.

ZAKLJUČEK

Ugotovili smo, da je sodelovanje v projektu Comenius-šolska partnerstva pozitivno vplival na spoznavni, motivacijski in socialni razvoj pri učencih. Neformalno sporazumevanje in timsko delo sta izboljšala odnose med učenci in učitelji. Sodelovanje v projektu je učencem omogočil splošen pregled nad šolami v drugih državah in nad načini, kako se učenci iz partnerskih šol soočajo s skupnimi nalogami. Ob tem so učenci razširili svoj angleški besedni zaklad s področja naravoslovja in izboljšali tekočnost angleščine.

REFERENCE

Angleščina – učni načrt

ENERGY THROUGH DAYS OF ACTIVITIES / TEDEN NARAVOSLOVNIH DEJAVNOSTI

Alma Gregorič

OŠ Lucijana Bratkoviča Bratuša Renče

alma.gregoric@guest.arnes.si

ABSTRACT

In April 2009 a Primary School Renče carried out a week of natural science activities on the topic of »Energy« for students from sixth to ninth grade. In each class we have choise a substantive theme depending on the aims set out in the syllabus related to the issues of energy.

The emphasis was placed on experimental and research work; the designing and manufacturing of products as well as operation and applicability checking; problem-oriented and differentiated tasks. Because of inter-subjects plan of activities, beside reaching our aims at these natural science subjects, the aims in other subjects were realised as well. Children were very active throughout the entire process and have shown a lot of enthusiasm.

Keywords: *Natural science activities week.*

UVOD

Ko smo se pred nekaj leti na Osnovni šoli Lucijana Bratkoviča Bratuša vključili v projekt Fleksibilni predmetnik, nam je bila dana možnost strnjenih oblik poučevanja, več medpredmetnega povezovanja, pogostejše vključevanje aktivnih oblik dela, kar je za učence pomenilo zanimivejši pouk. V šolskem letu 2007/ 2008 smo izvedli teden dejavnosti, ki smo ga v lanskem šolskem letu še nadgradili. V tednu naravoslovnih dejavnosti so učenci od šestega do devetega razreda obravnavali energijo tako, da so izvajali dejavnosti pri različnih predmetih in tako tudi dosegali cilje, ki jih določajo učni načrti tako naravoslovnih kot tudi ostalih predmetov.

METODA

Učenci 6. razreda so v tednu naravoslovnih dejavnosti spoznavali elektriko, električni krog, električni tok ter iskali možnosti varčevanja električne energije. Sestavljali so električni krog, eksperimentalno ugotavljali, kaj vpliva na jakost električnega toka in kateri so največji porabniki električne energije v gospodinjstvu. Pri urah tehnike in tehnologiji so izdelali izdelek, ki je vključeval električni krog, pri gospodinjstvu so merili porabo električne energije različnih aparatov. Pri slovenščini so sestavili anketo, s katero so zbirali podatke o porabi in varčevanju električne energije. Zbrane podatke so pri matematiki obdelovali in razvrščali v tabele. Anketo so prevedli tudi v angleščino ter se naučili nekaj sloganov o varčevanju električne energije. Pri geografiji so se učili o elektrarnah, ki proizvajajo električno energijo. Ob koncu tedna so pri likovni vzgoji in slovenščini oblikovali zgibanko, s katero so predstavili dejavnosti celega tedna.

V 7. razredu je bila tema »Sonce je vir energije«. Obravnavali so pomen sončne svetlobe za fotosintezo. Načrtovali in izvedli so poskuse, s katerimi so dokazovali vpliv svetlobe na potek fotosinteze. Temo so nadgradili z naravoslovnim dnevom o gozdu, kjer pa so poleg pomena svetlobe in procesa fotosinteze obravnavali in določali drevesne vrste, grme v naših gozdovih, mahove, lišaje, pogostost pojavljanja lišajev ter vzroke za njihovo rast. v gozdu so spoznali tudi najpogostejše prebivalce: sesalce, ptiče, žuželke… V okviru geografije so obravnavali gozdove v drugih toplotnih pasovih. Zbirali so podatke o temperaturah in količini padavin v nekaj krajih ter za te kraje izdelali klimogram. Pri urah slovenščine in geografije so iskali povezavo med imeni drevesnih vrst in imeni krajev. S pomočjo virov so zbirali informacije o izkoriščanju sončne energije, izdelali so načrt za sončni kolektor in vsak učenec je po svojem načrtu sončni kolektor tudi izdelal ter preizkusil njegovo delovanje.

V 8. razredu so obravnavali goriva, gorenje ter problematiko izgorevanja fosilnih goriv. Pri kemiji so z eksperimentom spoznali lastnosti nekaterih goriv ter jih med sabo primerjali. Na osnovi simulacije efekta tople grede so spoznavali, da toplogredni plini vplivajo na segrevanje ozračja ter ugotavljali povezave s podnebnimi spremembami. To je bil vzrok, da so se z igro vlog pripravili in z argumenti zastopali svoja stališča na okrogli mizi o podnebnih spremembah. Z medpredmetno povezavo fizike, angleščine, likovne vzgoje ter tehnike in tehnologije pa so iskali možnosti izkoriščanja energije vetra ter kako s toplotnimi izolatorji zmanjšati izgube energije.

Učenci 9. razreda so obravnavali energijo skozi dve temi in sicer »Elektrika« ter »Hrana kot vir energije«. Pri elektriki so se posvetili obnovljivim virom energije: izdelovali so veternice, računali izkoristek energije vetra ter energijo sončne celice. V okviru tematike »Hrana kot vir energije« so učenci z medpredmetno povezavo in prepletanjem učnih ciljev in vsebin kemije in biologije spoznavali, kaj se dogaja s hrano po zaužitju. Tako so učenci istočasno obravnavali vsebine, ki so neločljivo povezane, kar jim je omogočalo lažje razumevanje procesa presnove v človeškem organizmu. Eksperimentalno so dokazovali hranilne snovi v različnih živilih ter snovi. Eksperimentalne vaje so bile diferencirane tako, da so učenci višjega nivoja imeli problemsko zasnovano nalogo z načrtovanjem in izvedbo eksperimenta, učenci nižjega nivoja pa so eksperimentalno nalogo izvajali po navodilih. Računali so vnos energije s hrano ter porabo energije pri različnih aktivnostih. Svoje ugotovitve so učenci predstavili na plakatih tako, da je bilo moč uvideti celotnost razumevanja obravnavanih vsebin. Pri jezikih so se devetošolci v tem tednu pripravili in z igro vlog izvedli okroglo mizo o (ne)zdravi prehrani mladostnikov.

REZULTATI

Čeprav ob zaključku tedna dejavnosti nismo sistematično vrednotili osvojenega znanja v tem tednu, menimo, da je takšno celostno učenje učinkovitejše, trajnejše, proces učenja pa za učence in učitelje zanimivejši. Ob koncu tedna so učenci v anketi izrazili svoje navdušenje nad tednom dejavnosti, predvsem zaradi aktivnega, razgibanega in zanimivega dela. Tudi učitelji smo ta teden ocenili zelo pozitivno, predvsem z vidika izjemne motiviranosti učencev za učenje. Pozitivno presenečeni smo bili nad dosežki učencev, ki se sicer soočajo z učnimi težavami.

ZAKLJUČEK

Organizacija takšnega tedna dejavnosti zahteva od učiteljev timsko načrtovanje, medsebojno usklajevanje in prilagajanje. Urnik je potrebno v celoti spremeniti in ga uskladiti glede na teme oz. zastavljene cilje po posameznih predmetih. Urnik smo imeli samo učitelji, medtem ko učence v tem tednu nismo seznanjali, kateri predmeti so na urniku. Sproti so bili obveščeni, kaj morajo prinesti naslednji dan k pouku in kakšne obveznosti imajo do naslednjega dne. Ker učenci teh zadolžitev niso dojemali kot »klasične« domače naloge, so svoje delo doma dobro opravili in redno prinašali v šolo vse potrebne pripomočke.

Četudi celostni, medpredmetno in problemsko naravnani pouk, zahteva od učiteljev veliko več priprav, smo bili učitelji enotnega mnenja, da dobri rezultati, motiviranost učencev ter izraženo zadovoljstvo učencev, učiteljev in staršev kažejo na to, da smo na pravi poti in je vredno tak način dela v bodoče nadgrajevati in širiti.

Zahvaliti se moramo pedagoškim svetovalcem iz Zavoda za šolstvo za strokovno pomoč, sodelovanje, nasvete in aktivno vključevanje v pedagoški proces.

TO PROMOTE ENVIRONMENTAL RESPONSIBILITY
/
SPODBUJANJE K OKOLJSKI ODGOVORNOSTI

Leonida Gregorič

OŠ Dornberk

gbogdan@siol.net

ABSTRACT

The paper presents an example of project research work in the field of natural science. The project was carried out by second and fourth class pupils. This research project aims at involving pupils in terms of active support in order to resolve problems so as to make our planet safer and cleaner. The pupils found out that their support can be provided in many different ways: by reducing waste, choosing environment-friendly products, and nevertheless by fighting for a cleaner and greener future. They also found out that an enormours amount of fuel is burnt by cars, vans, planes and other means of transportations. In the future, what needs to be taken into consideration is to make use of biofuel so as to reduce the pollution. The pupils with the assistance of the tutor produced cars and other means of transportations that will use solar or electric energy instead of petrol or fossil fuels and thus they will be environment-friendlly means of transportations. While working, the pupils showed a great amount of interactional collaboration and help. While producing their products, the pupils showed their prior knowledge, they helped each other and shared their experiences.

Keywords: *pollution, a greener future, means of transportation, energy, natural science.*

UVOD

Moj glavni namen tega projekta je bil, da bi prav vsi učenci spoznali kako lahko vsaka družina privarčuje nekaj energije, če namesto avtomobila občasno uporablja druge oblike prevoza. Javni prevoz je lahko hiter, varen in manj škodljiv za naše okolje. Kdor potuje z javnimi prometnimi sredstvi kot so avtobusi, tramvaji in vlaki, povzroči do 100 krat manj onesnaženja kot tisti, ki se vozi sam v avtomobilu. Mnoga mesta uvajajo električne vlake, tramvaje in enotirne železnice, ki ne izpuščajo škodljivih plinov v zrak in ki povzročajo tudi manjše zvočno onesnaženje.

Učenci so od doma prinesli najrazličnejše revije, časopise, prospekte, knjige, vse na temo onesnaženi planet. Naloga učitelja je, da jih vodi, usmerja in spodbuja pri iskanju neznanega. Z uporabo razne literature in aktivnim sodelovanjem in vključevanjem učencev v različne dejavnosti učitelj pripelje učence do boljše naravoslovne pismenosti.

Z veliko motivacije in željo po iskanju različnih rešitev za izdelavo prevoznih sredstev okolju prijaznih, so se lotili dela in pri tem zelo uživali. Pri delu so razvijali tudi pozitivne medsebojne odnose in pozitivno samopodobo.

METODA

Z učenci smo se pogovarjali o prometu, prometnih sredstvih nekoč in danes. Ugotovili so, da so prvotni načini pogonov vozil temeljili na sili vetra, vodnega toka in človeških mišic, zato onesnaževanja ozračja skoraj ni bilo. V knjigah in literaturi, ki so jo imeli na razpolago so poiskali vire in spoznali, da je z razvojem človek začel uporabljati premog in les. Začeli so uporabljati nerodne parne lokomotive. Tako so tudi po železnicah lahko prevažali zelo težke tovore. Z vlaki so lahko povezovali vsa mesta. Število vozil v cestnem prometu je naraščalo. Vključno z iznajdbo kolesa z zračnico in kočij so začeli graditi gladke in bolj kvalitetne ceste. Najnovejšo obliko prevoznih sredstev pa je predstavljal zračni promet in sicer baloni, nato pa letala. Ta so zelo hitro izpodrinila in nadomestila potniške ladje. Nekoč le sanje, so postale resničnost. Letala so povzročila pravo revolucijo v prometu in pospešila razvoj znanosti. Sodobni sistem prometa je tako zapleten, da ga morajo nadzorovati avtomatsko. Pri tem pomagajo človeku računalniki, elektronska komunikacijska sredstva in zasloni pa tudi alarmni sistemi.

Prevozna sredstva v preteklosti niso onesnaževala okolja, zraka. Danes pa je naš planet v nevarnosti zaradi takih onesnaževalcev kot so prevozna sredstva.

Učenci so odgovarjali na zastavljena vprašanja v zvezi z onesnaževanjem okolja nekoč in danes. Narisali so prevozna sredstva nekoč in danes in jih izrezali ter prilepili na plakat. Nekateri učenci so sestavili rime in jih tudi zapisali. Prav vsak učenec si je iz odpadne embalaže izdelal prevozno sredstvo prijazno okolju, ki jih poganjajo snovi, ki ne povzročajo škode).

REZULTATI

Cilje, ki sem si jih zastavila, so bili realizirani. Skupaj z učenci smo načrtovali skico projektnega učnega dela, s katero smo si pomagali pri izvajanju projekta Med izdelovanjem skice so se učenci pogovarjali, izmenjavali ideje in mnenja ter dajali predloge za potek projekta. Literature na to temo smo imeli veliko, zato so se učenci veliko novega naučili. Ogledali smo si železniško postajo, pogovarjali s policistom, risali prevozna sredstva nekoč in danes. Poleg prevoznih sredstev so učenci našteli glavne onesnaževalce okolja, ki so že nevarni za naš planet. Te so tudi narisali: tovarne, onesnaževanje vode, nuklearno industrijo, jedrske elektrarne, gospodinjske kemikalije…

Učenci so spoznali, da nekatere onesnažujoče kemikalije imajo takojšnje učinke, nekateri najnevarnejši učinki pa prizadenejo naša telesa in duševnost. Kemikalije v zraku, vodi, živilih in pijačah ko pridejo v telo, povzročijo včasih trajno škodo.

Novo izrazoslovje je prispevalo k večji naravoslovni pismenosti vsakega posameznika.

ZAKLJUČEK

Učenci so s svojimi praktičnimi izdelki pokazali svoje ideje in znanja, ki so jih pridobili. Z analizo in primerjavo njihovih izdelkov smo ugotovili, da so uresničili zastavljene cilje. Izdelava prometnih sredstev je razvila pri učencih smisel za konstrukcijo, načrtovanje in gradnjo. Pri tem so učenci pridobivali nova spoznanja, izkušnje in predstave. Do izraza je prišla medsebojna pomoč, sodelovanje in dogovarjanje. Učenci so se med izdelovanjem dopolnjevali in izmenjavali izkušnje. Preko tehnike so spoznavali primeren odnos do dela in do drugih sošolcev. Razvijali so tudi moralne norme. Delo je potekalo v prijetnem vzdušju in končni izdelki so nam bili v velik ponos.

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EUROPEAN PROJECT TRANSFER OF INOVATION "HANDS-ON APPROACH TO ANALYTICAL CHEMISTRY FOR VOCATIOBAL SCHOOLS" / EVROPSKI PROJEKT PRENOSA INOVACIJ "IZKUSTVENI PRISTOP K ANALIZNI KEMIJI ZA STROKOVNE ŠOLE II"

Nataša Gros

Univerza v Ljubljani, Fakulteta za kemijo in kemijsko tehnologijo

Natasa.Gros@fkkt.uni-lj.si

Margareta Vrtačnik

Univerza v Ljubljani, Naravoslovnotehniška fakulteta

metka.vrtacnik@guest.arnes.si

ABSTRACT

In the study preliminary results on the impact of students' motivational profiles and their knowledge gained through hands-on approach to visual spectroscopy, are presented. The modules were developed during the Leonardo da Vinci project »Hands-on Approach to Analytical Chemistry for Vocational Schools«, 2003-2005, while the evaluation study is a part of the ongoing project »Hands-on Approach to Analytical Chemistry for Vocational Schools II, 2008 – 2010, in which partners from the University of Bristol, UK, the University of Gdansk, Poland, and the University of Ljubljana are developing new experiments for transfer of innovations into vocational schools.

Keywords: *hands-on approach, visual spectroscopy, motivational profiles*

UVOD

Evropski Leonardo da Vinci projekt Prenosa inovacij z naslovom »Izkustveni pristop k analizni kemiji za strokovne šole II« združuje partnerje z Univerze v Ljubljani, Univerze v Bristolu in Univerze v Gdansku ter slovenske strokovne šole s področja živilstva, kemije in farmacije. Jedro prenosa inovacije je spektrometer Spektra^{TM}, ki je rezultat slovenskega znanja (Gros, 2004) in omogoča hitro in varno eksperimentiranje, z majhnimi količinami kemikalij. Podloge imenovane blistri, v katere v farmacevtski industriji pakirajo dražeje, služijo kot reakcijske in merilne komore. Spektrometer je enostavno mogoče nadgraditi v druge analizne instrumente, kot sta na primer plinski in tekočinski kromatograf. Projektni partnerji razvijajo eksperimente za izkustveno učenje zelo različnih strokovnih in naravoslovnih vsebin ter jih objavljajo na spletni strani projekta (http://www.kii2.ntf.uni-lj.si/analchemvoc2/file.php/1/HTML/slo/default.htm). Doslej je bilo razvitih približno 50 eksperimentov. Eksperimenti so s področja svetlobe in barv, analize vod in zemlje, analize živilskih proizvodov in pijač, biotehnologije, analize materialov, kemijskega ravnotežja in kinetike, kromatografije ter naravoslovja. Strokovne šole uvajajo in preverjajo učno enoto »Izkustveni pristop k spektrometriji v vidnem področju« s svojimi dijaki. Ob tem izvajamo sistematično evalvacijsko študijo, ki vrednoti vpliv takih pristopov na motiviranost in znanje dijakov. Vansteenkiste s sodelavci (2009) so s klasifikacijo rezultatov motivacijskih vprašalnikov po metodi K-tega najbližjega soseda ugotovili, da lahko učečo se populacijo, glede na vrednosti avtonomne in kontrolirane motivacije, razdelimo v štiri motivacijske skupine oz. profile: (a) *skupina dobre kvalitete* – z visoko avtonomno motivacijo in nizko kontrolirano motivacijo, (b) *skupina nizke kvalitete* - z nizko avtonomno in visoko kontrolirano motivacijo, (c) *skupina nizke kvantitete* – z nizko avtonomno in nizko kontrolirano motivacijo in (d) *skupina visoke kvantitete* – z visoko avtonomno in visoko kontrolirano motivacijo. Največji učinek na študijske uspehe se je pokazal pri motivacijski skupini *dobre kvalitete*.

METODA

Izbrane module »Izkustvenega pristopa k spektrometriji v vidnem področju«, ki so zasnovani kot aktivna oblika šolskega dela, so dijaki predelali ob samostojnim izvajanjem poskusov in ob sprotnem preverjanju pravilnosti rezultatov. Pred izvedbo modulov so pisali pred-test in po končani izvedbi po-test ter motivacijski test (Juriševič, M. in sodelavci, 2008). Z raziskavo smo želeli: (a) opredeliti motivacijski profil testirancev in (b) ugotoviti povezanost motivacijskega profila s splošnim znanjem kemije (predhodnim učnim uspehom) ter s specifičnim znanjem s področja spektrometrije v vidnem področju, ki so ga dijaki pridobili z izkustvenim pristopom. Kot merske inštrumente smo uporabili pred-test, po-test in vprašalnik motivacije in odnosa do izkustvenega pristopa. Motivacijski vprašalnik sestavlja 41 trditev, do katerih se testiranci opredelijo s pomočjo petstopenjske Likertove lestvice (1- zame ta trditev gotovo ne velja, 5 - zame ta trditev zagotovo velja). S trditvami vprašalnika preverjamo raven avtonomne (notranje, identificirane in regulirane motivacije) in kontrolirane motivacije (zunanje in injicirane) testirancev, njihovo samopodobo in odnos do izkustvenega pristopa. V raziskavi je sodelovalo 77 dijakov dveh srednjih strokovnih šol, ki sta vključeni v projekt. Njihova povprečna starost je bila 16,9 let.

REZULTATI

Klasifikacija dijakov glede na vrednosti kontrolirane in avtonomne motivacije (notranje in regulirane) ter samopodobe z metodo K-tega najbližjega soseda pokaže, da lahko dijake glede na izbrane klasifikacijske kriterije razdelimo v tri skupine. Za dijake, ki pripadajo I. skupini, je značilna nadpovprečno visoka samopodoba (3,39) ter visoka avtonomna (notranja 3,94 in regulirana 3,88) motivacija in podpovprečna kontrolirana motivacija (2,67). Ti dijaki se uvrščajo v motivacijsko skupino *dobre kvalitete*. Dijaki II. in III. skupine sodijo v skupino *nizke kvalitete* (nadpovprečna kontrolirana motivacija (3,39 oz. 3,56) in podpovprečna avtonomna motivacija (notranja 2,11 oz. 2,63 in regulirana 2,48 in 2,88). Skupini se razlikujeta glede na vrednost samopodobe, ki je za dijake II. skupine 2,18, za dijake III. skupine pa 3,36. Slednji dijaki imajo bolj pozitiven odnos do svojih učnih sposobnosti. Na pred-testu med dosežki treh motivacijskih skupin razlike niso bile statistično pomembne. Na po-testu so se pokazale statistično pomembne razlike med različnimi motivacijskimi profili dijakov. Dosežki dijakov motivacijske skupine *dobre kvalitete*, so na ravni signifikantnosti 0,01 boljši od dosežkov dijakov II. skupine in na ravni signifikantnosti 0,05 boljši od dosežkov dijakov III. Skupine. Na po-testu so nadpovprečen rezultat dosegli samo dijaki I. skupine, kar potrjuje vpliv motivacijskega profila na učne rezultate. Statistično pomembne razlike med šolama A in B na ravni signifikantnosti 0,01 so se pokazale le pri dosežkih dijakov na po-testu (šola A 52,2%, šola B 81 %). Ugotovili smo, da ima na razlike v dosežkih tudi v tem primeru vpliv motivacijskih profil dijakov dveh šol. S t-testom smo dokazali statistično signifikantnost razlik med avtonomno in kontrolirano motivacijo dijakov šol A in B na ravni signifikantnosti 0,01. Dijaki šole A se uvrščajo glede na nadpovprečno visoko vrednost kontrolirane motivacije 3,4 in podpovprečno avtonomno motivacijo (regulirana, 2,8 in notranja 2,6) v motivacijsko skupino *nizke kvalitete*, ki imajo tudi podpovprečno samopodobo (2,9). Nasprotno se dijaki šole B uvrščajo v motivacijsko skupino *dobre kvalitete* (visoka avtonomna motivacija: regulirana, 3,7 in notranja 3,6, ter nizka kontrolirana motivacija 2,7). Ti dijaki imajo hkrati tudi nadpovprečno samopodobo 3,7.

ZAKLJUČEK

V raziskavi sta bila identificirana dva motivacijska profila dijakov; motivacijski profil *dobre kvalitete* in *nizke kvalitete*; dijaki v slednji skupini se razlikujejo po samopodobi. Raziskava je potrdila rezultate predhodnih, da imajo najboljše učne uspehe tisti dijaki, ki se uvrščajo v motivacijsko skupino *dobre kvalitete*, tem dijakom tudi najbolj ustreza avtonomni stil poučevanja, ki se je odrazil na rezultatih po-testa. Učinka avtonomnega stila poučevanja (izkustveni pristop) na dosežke dijakov v motivacijsko slabših skupinah dijakov (II. in III. skupina), nismo dokazali. Pokazale so se statistično pomembne razlike med šolama A in B pri dosežkih dijakov na po-testu. Povprečni dosežki dijakov šole B (81 %) so bili statistično pomembno boljši od dijakov šole A (53 %). Glede na vrednosti kriterijev motivacijskega profila se pokaže, da se dijaki šole A uvrščajo v motivacijsko skupino *nizke kvalitete*, dijaki šole B pa v motivacijsko skupino *dobre kvalitete*, zato njihov boljši dosežek na po-testu ni presenetljiv.

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LIGHT POLLUTION
/
SVETLOBNO ONESNAŽEVANJE

Marija Jakelj

OŠ Josipa Vandota Kranjska Gora

marija.jakelj@guest.arnes.si

ABSTRACT

Light pollution is impact of artificial light on the environment. It is obvious that excessive lighting has a number of harmful effects on numerous organisms (bats, insects, plants, deer, turtles, amphibious animal), astronomical observations and public health. Furthermore we waste energy with installing lamps for external illumination, shining directly or indirectly into the sky. Pupils of 7th class have made research using methods such as: counting various types of lamps, measuring of illumination, taking photos with digital camera, interviewing competent people, searching data on the net, editing data and measurements in the charts and evaluating results.

Keywords: *light pollution, shaded lamps, unshaded lamps.*

UVOD

Onesnaževanje neba oz. nasploh naravnega okolja z umetno svetlobo je pomembno ekološko, vprašanje. Z obravnavanjem te tematike sledimo splošnim ciljem učnih načrtov prek okoljske vzgoje, tehnike in naravoslovja, ter naravoslovja v 6. in 7. razredu: razvijati sposobnost za zaznavanje in razumevanje ekoloških problemov, razvijati odgovoren odnos do okolja in spodbujati interes za njegovo aktivno varovanje, razvijati spoštovanje do vseh oblik življenja in razumevanje medsebojne povezanosti žive in nežive narave, ter spodbujati kritično presojanje o škodljivosti in negativnem vplivu pretiranih človeških posegov v naravno okolje.

METODA

V 7. razredu ponudim učencem pojem svetlobnega onesnaževanja predvsem kot dodatno delo pri poglavju svetloba.

O svetlobnem onesnaževanju se je začelo govoriti predvsem zaradi onemogočanja raziskovalne in poljudnoznanstvene dejavnosti astronomskih observatorijev. Prvi je na ta problem opozoril astronom Herman Mikuž. Učinek onesnaževanja je žarenje neba, ki je odvisno od meteoroloških pojavov in količine prahu v ozračju. Pokažem jim nekaj vzrokov svetlobnega onesnaževanja: cestne svetilke, okrasna razsvetljava, reklamni panoji, reflektorji in laserji, nepravilno osvetljevanje bivalnih okolij.

Opredelitev nalog:

Učenci sami oblikujejo predstavitev, ki vključuje:

Anketiranje občanov, poiščejo primere slabih in dobrih svetilk in jih fotografirajo, raziščejo posledice svetlobnega onesnaževanja na ljudi in živali, predlagajo ukrepe za zmanjšanje svetlobnega onesnaževanja. Dejavnosti učencev: meritve z luxmetrom, urejanje podatkov in meritev v razpredelnice, analiza rezultatov, štetje raznovrstnih svetilk, dokumentiranje z digitalnim aparatom, ankete in intervjuji s pristojnimi ljudmi, uporaba ustrezne literature, brskanje po svetovnem spletu.

REZULTATI

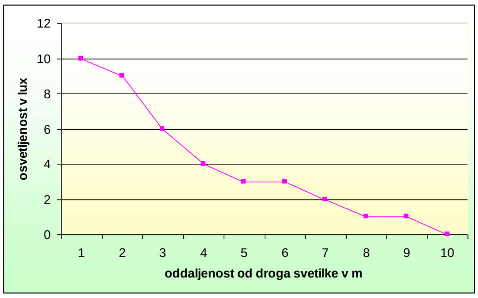
V občini je 430 stoječih nezasenčenih svetilk, 330 stoječih delno zasenčenih svetilk, 7 reflektorjev in 9 talnih svetilk.

Z luxmetrom merimo svetlost osvetljene ploskve, torej, osvetljenost. Merimo lahko osvetljenost glede na oddaljenost od droga svetilke, osvetljenost učilnic in šolskih prostorov.

Cestna delno zasenčena svetilka - Tabela 1

oddaljenost od droga svetilke (m)	1	2	3	4	5	6	7	8	9	10
osvetljenost (lux)	10	9	6	4	3	3	2	1	1	0

Višina droga svetilke je 6m.



Če je razdalja med svetili 2,5-krat večja od njihove višine, so tla osvetljena dovolj enakomerno. S takimi nizi je osvetljena večina slovenskih cest. Med vožnjo po njih žal vidimo ves niz svetilk pred nami, kar nam zmanjšuje kontrast in otežuje razpoznavanje nekontrastnih objektov (pešci). Svetila so vidna od daleč. Poleg energijskih izgub to pomeni oviro za živali in seveda ljudi (bleščanje).

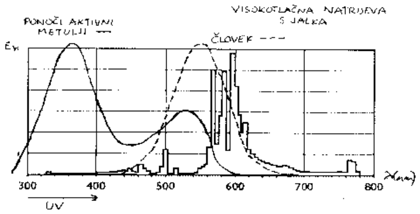
Cestna razsvetljava

Slika1 -Primer dobre svetilke **Slika2 - Primer slabe svetilke**

Posledice svetlobnega onesnaževanja so ekonomske, zdravstvene, astronomske in ekološke.

Svetlobno onesnaževanje je eden od dejavnikov, ki ogroža biotsko raznovrstnost.

Vpliv svetlobnega onesnaževanja na žuželke



Spekter visokotlačne natrijeve sijalke in občutljivost človeškega očesa ter oči nočno aktivnih metuljev.

ZAKLJUČEK

Učenci sami ugotovijo, da bomo svetlobno onesnaževanje zmanjšali, če ne osvetljujemo preveč, če ugašamo luči, ki jih ne potrebujemo, svetlobo usmerimo naravnost navzdol na cilj osvetlitve, osrednji žarek mora biti usmerjen navpično na tla, svetlobo je treba omejiti nad vodoravno smerjo in nameščati natrijeve svetilke, ki ne svetijo belo. Vedno bolj očitno je, da ima pretirano osvetljevanje škodljive vplive na številne organizme (netopirje, žuželke, ptice, rastline, divjad, želve, dvoživke), astronomska opazovanja in zdravje ljudi. Z nameščanjem svetilk za zunanjo razsvetljavo, ki svetijo posredno ali neposredno v nebo, pa poleg omenjenega, tudi nesmiselno trošimo energijo.

Učenci so s to projektno nalogo spoznali, da ljudje še premalo poznajo problem svetlobnega onesnaževanja. K izboljšanju stanja lahko pripomore upoštevanje določb iz Uredbe o mejnih vrednostih svetlobnega onesnaževanja.

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MAKING FLOATING CANDLES
/
IZDELAVA PLAVAJOČIH SVEČK

Vida Jaušovec

OŠ Neznanih talcev Dravograd

vida.jausovec@guest.arnes.si

ABSTRACT

The pupils in the seventh class of primary school are within the chemical–physical contents at the school subject natural science introduced also with the topics of the melting and boiling point.

To improve pupils' comprehension of those two abstract terms, I have decided to prepare the experiment – the making of the floating candles. Pupils see and use the paraffin wax in solid state, they melt it on the water bath and with the help of thermometer they practically find out its melting point. Furthermore they add some colours in solid and perfumes in liquid state. The liquid paraffin wax is then poured into the models of different shapes and cooled down till its solidification.

Through this experiment pupils' understanding of physical states of substances, transitions between different states as well as both terms, the melting and the boiling point, is consolidated.

Keywords: *experimental work, physical state, transitions between different states, the melting point, the boiling point.*

UVOD

Pri učnem predmetu naravoslovje v 7. razredu osnovne šole imamo v okviru kemijsko-fizikalnih vsebin tudi razlikovanje med fizikalnimi in kemijskimi spremembami. Fizikalne spremembe so tudi spremembe agregatnih stanj, ki jih dosežemo s prehodi preko tališča in vrelišča. Učenci poznajo tališče in vrelišče vode, težave pa imajo pri poznavanju tališč in vrelišč drugih snovi. S tem namenom smo se pri tej vaji lotili določanja tališča in vrelišča parafina, ki ga učenci srečujejo v vsakdanjem življenju. Ker pri vaji uporabljamo vodno kopel, lahko primerjajo prehode med agregatnimi stanji obeh snovi.

METODA

Da bi dosegla boljše razumevanje te učne snovi sva s kolegico pripravili laboratorijsko vajo «Izdelovanje plavajočih svečk«. Učenci so s pomočjo delovnega lista (Prikaz 1) in navodil opravili vajo, Ob eksperimentalnem delu so si podatke zapisovali in koncu pripravili poročilo o vaji, ki so ga lahko oblikovali in dokončali po delu, Osnutek zanj (Prikaz 2) so dobili pred vajo.

REZULTATI

Učenci so s pomočjo navodil izbrali ustrezna sredstva in pripomočke za izdelavo plavajoče svečke. Pripravili so vodno kopel, s katero so stalili parafin. Izmerili so njegovo tališče in ga primerjali s tališčem, zapisanim v literaturi. Tekočemu parafinu so dodali barvila v trdnem agregatnem stanju. V modelčke so vstavili stenj, nanj vlili obarvan parafin, lahko tudi v več plasteh in različnih barv. Pri tem postopku so samostojno ugotovili, da se plasti med seboj prelivajo in da je smiselno počakati, da se prejšnja plast parafina že malo strdi in se plasti lepše ločijo. Ob razgovoru ugotovijo, da temperaturne točke vrelišča ne bomo mogli praktično izmeriti in da bo parafin to točko dosegel, ko bo svečka gorela.

ZAKLJUČEK

Ob tem delu sem dosegla, da so učenci usvojili znanja o snoveh, njihovih agregatnih stanjih ter prehodih med njimi. Pri laboratorijskem delu utrdimo in upoštevamo načela varnega dela, prav tako pa tudi pomen in zaporedje posameznih etap dela. Učenci se navajajo na urejenost delovne površine, sprotno zapisovanje podatkov ter končno poročanjem pred razredov. Naučijo se pisati laboratorijsko poročilo. Pri tem delu lahko izrazijo smisel za estetiko ter predlagajo izboljšave, npr. dodajanje eteričnih olj, da dobimo plavajoče dišeče svečke. Ob kasnejšem preverjanju se je izkazalo, da učenci bolje razumejo in razlagajo teoretska znanja o snoveh, njihovih fizikalnih in kemijskih spremembah, agregatnih stanjih ter prehodih med njimi.

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PRIKAZ 1: Delovni list 1

VAJA: IZDELOVANJE PLAVAJOČIH SVEČK

Navodilo za delo:

Natančno preberi nalogo in potek dela ter pozorno poslušaj učiteljeva navodila, šele nato prični z delom.

Tvoja naloga je:

Izdelaj si plavajočo svečko, pri čemer ugotovi temperaturo parafina iz katerega boš izdelal/-a) svečko in opazuj spremembe agregatnih stanj.

Za delo potrebujem (material in pripomočki): *(Zabeleži si ob poteku dela.)*

-	-
-	-
-	-
-	-

Potek dela:

1. Na vodni kopeli stalimo parafin, pri čemer s pomočjo termometra ugotovimo temperaturo tališča parafina. *Pazimo, da parafina ne pregrejemo!*
2. Ko je ves parafin staljen, ga poljubno obarvamo s pomočjo posebnih barv v obliki tabletk. Parafin mešamo, da se barva enakomerno porazdeli.
3. Tako obarvan parafin vlivamo v naprej pripravljene plastične modelčke.
4. Vstavimo stenj.
5. Napolnjene modelčke pustimo nekaj časa mirovati.

Skice dela:

Opiši svoja opažanja in ugotovitve.

____

Diskusija (razlaga):

- Katere fizikalne postopke smo izvajali?

____

- Katere fizikalne spremembe si opazil/-a) in zakaj je prišlo do njih?

____

- Katere lastnosti agregatnih stanj si lahko opazil/-a?

____

PRIKAZ 2: Delovni list 2

Kako naj napišem laboratorijsko poročilo o tej vaji?

1. UVOD

a) *Teoretske osnove* – v knjigah, leksikonih, učbenikih,… poiščeš in zapišeš informacije:

- spremembe agregatnih stanj,
- poimenovanje prehodov med agregatnimi stanji,
- značilnosti posameznih agregatnih stanj,
- tališče snovi,
- parafin – kaj je to, kako ga pridobivajo,…

b) Namen:

Eksperimentalno ugotoviti temperaturo tališča parafina in opazovati spreminjanje agregatnih stanj le-tega.

2. METODE DELA

a) *Material in pripomočki:* Naštej vse kar si potreboval/-a za izvajanje eksperimenta.

b) *Potek dela:* Natančno opišeš kako smo (ste) delali.

c) *Skice dela:* Narišeš skice, ki si jih skiciral/-a ob eksperimentiranju.

3. REZULTATI

Zapišeš kakšen je bil rezultat dela na posameznih stopnjah:

- kaj se je zgodilo, ko smo parafin segrevali,
- kolikšna je temperatura tališča parafina,
- kaj se je dogajalo s parafinom, ko smo ga pustili mirovati pri sobni temperaturi

4. RAZLAGA, RAZPRAVA (DISKUSIJA)

V tem delu poročila razložiš rezultate s pomočjo teoretskih osnov zapisanih v uvodu:

- kaj se je zgodilo, ko smo parafin segrevali – *Zakaj?, Kako imenujemo ta prehod med agregatnimi stanji?*
- kolikšna je temperatura tališča parafina – *Zakaj takšna temperatura, kako smo jo ugotovili?*
- kaj se je dogajalo s parafinom, ko smo ga pustili mirovati pri sobni temperaturi – *Zakaj?, Kako imenujemo ta prehod med agregatnimi stanji?*

5. SKLEPI

Iz diskusije izpelješ končne ugotovitve (sklepe).

6. KRITIKA

Tu zapišeš:

- Kaj ti je bilo pri vaji všeč in kaj ne? Kaj bi spremenil?
- Kateri del vaje se ti je zdel lažji oziroma težji?
- Ali predlagaš, da bi še v prihodnje izvajali takšne vaje? Zakaj?

7. LITERATURA

Tu zapišeš podatke o knjigah, leksikonih, učbenikih,… (jih citiraš), ki si jih uporabil pri zapisu teoretskih osnov, npr., če si uporabil šolski učbenik lahko zapišeš takole:

- Kolman, A. idr. (2003). Naravoslovje 7, učbenik. Ljubljana: Rokus

WITH THE PROJECT LEARNING WORK TO ECOLOGICAL AWERNESS OF PUPILS
/
S PROJEKTNIM UČNIM DELOM K EKOLOŠKEMU OSVEŠČANJU UČENCEV

Alenka Kastelic

OŠ Rudolfa Ukoviča Podgrad

akastelic@gmail.com

ABSTRACT

The article presents a project in the ecology field. The project took three phases. Pupils recognized burning problems of enviroment pollution by means of didactis games, they sorted waste package and stated positive effects of separated waste collecting. They made some useful products out of the waste package and prepared posters about protecting the enviroment and the meaning of collecting the waste.

The author of the article states that the pupils have assimilated and deepened the recognitions of ecological problems, have recognized the meaning of care for the clean enviroment, have strenghtened the feeling for enviroment protection, have developed positive habits, creativity and interpersonal connections in a group. In this way they formed a positive and critical relation towards the science themes on the visual and cognitive levels.

Keywords: project learning work, enviroment pollution, waste package, a didactic game, useful products

UVOD

Problem onesnaževanja okolja z odpadki je iz dneva v dan večji in bolj zaskrbljujoč. V zadnjem času se tega vse bolj zavedamo, vendar se na tem področju stvari počasi premikajo v pozitivno smer. Spoznanje, da se nekatere odpadne snovi, z reciklažo in obdelavo lahko ponovno uporabijo, je izredno pomembno. Nujno je, da otroci to spoznanje skozi igro že zelo zgodaj uzavestijo in ga sprejmejo kot način življenja.

Skupaj z učenci smo opredelili različne poglede na odpadni material. Seznanili smo se s problemom in nevarnostmi divjih odlagališč smeti, ki lahko privedejo do zelo resnih in hudih problemov onesnaževanja. Učenci so spoznali, kaj je to embalaža in se jo naučili ločiti glede na to iz česa je. Seznanili so se z ekološkimi otoki, ki so namenjeni ločenemu zbiranju odpadkov. Tako smo jih spodbudili, da tudi sami skrbijo za razvrščanje odpadkov v domačem okolju. Pri učencih smo želeli vzbuditi občutek za skrbno ravnanje z odpadnimi snovmi in jih seznaniti s predelavo ter ponovno uporabo odpadnih materialov.

Učenci so spoznavali projektno učno delo, ugotavljali kako sami vplivajo na naravo, kako lahko dejavno prispevajo k varovanju in ohranjanju čistega okolja, kako nastajajo odpadki, za katere je potrebno poskrbeti, kako lahko odpadke sortiramo, recikliramo in ponovno uporabimo. Učenci so razvijali tudi ročne spretnosti ter tehnično ustvarjalnost. Gojili so ustvarjalnost in medsebojno povezanost v skupini.

METODA

Projekt je potekal s prvošolci v oddelku podaljšanega bivanja na način projektnega učnega dela. Potekal je v treh fazah. Učenci so bili aktivno vključeni v vse faze projekta, od postavitve problema, načrtovanja, priprave dela, preko izvedbe do vrednotenja izdelkov.

Z učenci smo v prvem delu najprej prebrali zelo poučno knjigo Mateje Reba z naslovom Jurček in packarija, ki na otrokom primeren način, prikaže aktualne vsebine s področja varstva okolja in ekologije. Igrali smo se tudi razne didaktične igre, ki so otrokom približale problem onesnaževanja okolja. Ker je otrok zvedavo bitje in ga zanima vse kar ga obdaja, smo v naslednjem koraku izkoristili ravno to značilnost. Učence smo vodili in usmerjali pri opazovanju bližnjega okolja ter s tem razvijali njegovo radovednost in iskanje, ki ga vodita k vedno bolj urejenemu spoznavanju okolja. Z učenci smo si najprej ogledali bližnjo okolico šole. Opazovanje je bilo načrtovano in usmerjeno. Učenci so bili zelo pozorni opazovalci. Videli so tudi najmanjše smeti, ki jih drugače sploh ne opazijo. Seveda smo odpadke sproti pobirali v vrečko. Napotili smo se do divjega odlagališča, kjer so učenci opazili zelo veliko nepravilno odloženih odpadkov. Ugotovili so, da to lahko naredi le človek, zato so bili zelo kritični. Pot nas je vodila v središče naselja, kjer smo si ogledali ekološki otok. Prebrali smo piktograme in napise na zabojnikih. Opazili smo, da se zabojniki ločijo tudi po barvi. Učenci so ugotovili, da ljudje bolje skrbijo za čisto okolico v samem naselju, kot izven naselja. Učenci so risali stvari, ki so se jim ob raziskovanju okolice najbolj vtisnile v spomin.

V drugem delu so razvrščali odpadno embalažo glede na določene lastnosti in ugotavljali pozitivne učinke ločenega zbiranja odpadkov. Po predhodnem dogovoru so učenci zbirali in prinesli v šolo najrazličnejšo embalažo. Ugotavljali so iz česa je (les, steklo, kovina, plastika, papir…) in jo glede na to tudi razvrščali. Spoznali so, da so lahko različni predmeti iz iste snovi ali da so enaki predmeti iz različnih snovi. Nekatere lastnosti snovi so določali s čutili (barva, otip, zven, vonj).

V zadnjem delu so iz odpadne embalaže izdelovali uporabne izdelke in oblikovali plakate o varovanju okolja in pomenu ločenega zbiranja odpadkov. V sklepnem delu so učenci izdelke kritično ocenili in jih postavili na razstavo. Z uporabo odpadnega materiala za izdelovanje izdelkov se je v učencih krepil občutek za varovanje okolja, učenci so razvijali ustvarjalnost in medsebojno povezanost v skupini.

REZULTATI

Učenci so z veseljem sodelovali pri delu. Pomembno se jim je zdelo, da so bili vključeni v projekt od ideje do vrednotenja in razstave. Vsakemu učencu je bilo omogočeno, da odkriva in uresničuje svoje zmožnosti ter pridobi občutek samozavesti in zadovoljstva ob uspešno opravljenem delu. Iz spoznanj in izkušenj, ki so jih učenci pri projektnem učnem delu dobili, lahko črpajo pobude za učenje in s tem širijo svoje znanje in ustvarjalnost.

Cilji projekta so bili doseženi. Učenci so bili s tako obliko dela zelo zadovoljni. Kljub temu, da so veliko delali, spoznali veliko novega, se veliko naučili, v delo vključevali vsa svoja čutila, niso imeli občutka, da so v šoli in da gre zares. Zadovoljili so potrebo po gibanju, druženju in izmenjavi izkušenj, medsebojni pomoči in znanju. Hkrati pa poglabljali spoznanja ekološke problematike, spoznavali pomen skrbi za čisto okolje, krepili občutek za varovanje okolja, razvijali pozitivne navade, oblikovali pozitiven in kritičen odnos do naravovarstvenih vsebin na vizualni ter spoznavni ravni.

ZAKLJUČEK

Prepričana sem, da s tem, ko so učenci spoznali prijazen in pozitiven odnos do okolja, obstaja večja možnost, da bodo spremenili odnos do narave in se naučili koristno uporabljati odpadne snovi in embalažo. Zavedam se, da je to le kapljica v morje. Toda, če ne bi bilo kapljice, tudi morja ne bi bilo.

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LIFELONG LEARNER AND CHEMISTRY
/
VSEŽIVLJENJSKI UČENEC IN KEMIJA

Zvonka Kladnik

JVIZ Mozirje, OE OŠ Rečica ob Savinji

Zvonka.kladnik@gust.arnes.si

ABSTRACT

At chemistry class examples from everyday life offer endless possibilities to us. Examples from everyday life may help explain and teach the majority of chemical laws and definitions, which otherwise the students find rather abstract and, in most cases, difficult to understand. The question: »Why are roads salted in winter?« Is taken from everyday life, if it is included in the learning process. While students learn about basic chemical laws and the concepts, which are prescribed by the curriculum for chemistry pupils are encorraged to think creatively. We use new knowledge about learning, taking into account the differentiation, stimulate creative thinking and prepare students for lifelong learners.

Keywords: *life-long learner, increase learning, understanding learning, understanding concept, creative thinking.*

UVOD

Učitelj lahko znanje ponudi, pripravi pripomočke za učenje, poskuša vzbuditi pozornost, vlaga napore v razmere, da bi bile te za učenje najprimernejše. Ne more pa se namesto učencev naučiti. Učenje je oseben proces. Koliko ponujenega znanja kdo sprejme, odloča vsak sam. Vendar pa je potrebno učenje pri učencih povečati, spodbujati pozitivna čustva in ga narediti zanimivega, da ga sprejemajo pozitivno in da to postane trajno. Vprašanje pa je, kaj poveča učenje. Pri opazovanju otrok v njihovem okolju lahko opazimo njihovo naravno radovednost in visoko stopnjo učenja pri dejavnostih, ki so jim zanimive. Ta opazovanja nam omogočajo načrtovanje učnega procesa, ki bo pri učencih vzpodbudil njihovo naravno potrebo po učenju. Izhodišče poučevanja bi moralo temeljiti na učenčevem predznanju, ki ga pri učnem procesu nadgrajujemo. Na ta način učenci nova spoznanja povežejo z že obstoječimi vedenji. Shulman (1986) pravi, da je učitelj tisti, ki bo preoblikoval znanstvena dogajanja v takšno obliko, da bo učencem razumljiva. Pri tem je osrednji element vedenje učiteljev, da znanstvene vsebine prilagodi različnim interesom in sposobnostim učencev in ga prenese v pouk. Za učitelje je pomembno, da vedo, kako učencem razložiti znanstvene pojme in koncepte. Razumevanje konceptov je pomembno v razvoju učenčevega razumevanja delovanja sveta. Tako Schmidt in Volke (2003) razlikujeta med definicijami, izrazi in pomenom konceptov. Saj kot pravita Pines in West (1986), koncepti, ki imajo drugačen pomen v znanosti in v vsakdanjem življenju, lahko učence zmedejo.

Zaradi tega je potrebno razmišljati, da pri učencih vključujemo v učenje teme, ki so pomembne za razumevanja vsakdanjega življenja in da tako ti postanejo vseživljenjski učenci.

METODA

Pri pouku kemije nam primeri iz vsakdanjega življenja nudijo nešteto možnosti. S primeri iz življenja lahko razložimo in naučimo večino kemijskih zakonitosti in definicij, ki so sicer za učence dokaj abstraktne in v večini primerov težko razumljive. Z usmerjenim pristopom poučevanja, poskušam pri učencih v učenje vključevati teme, ki so pomembne v življenju.

Vprašanje: »Zakaj pozimi solijo ceste?« je vzeto iz življenja, če ga vključimo v učni proces in izvedemo kot problemski pristop, spodbujamo kreativno razmišljanje, pri tem učenci spoznavajo osnovne kemijske zakonitosti in pojme, ki jih predpisuje učni načrt za kemijo. Uporabimo nova vedenja o učenju, upoštevamo diferenciacijo, spodbujamo kreativno razmišljanje in pripravimo učence za vseživljenjske učence.

Učencem postavim omenjeno problemsko vprašanje, za katerega morajo predvideti hipotetičen odgovor in ga nato z eksperimentom preveriti. Pripraviti morajo načrt raziskave in jo izvesti. Po raziskavi - eksperimentu, dobijo odgovore na nekatera vprašanja, kot so: znižanje tališča in pomen le- tega v vsakdanjem življenju. Ta način dela od učencev zahteva:

- da se odločajo o možnih rešitvah,
- da se odločajo za najboljšo rešitev,
- da utemeljijo pravo izbiro,
- da poročajo o tem, kaj so se naučili o dejavnosti (ne o vsebini, temveč procesu).

REZULTATI

Po končanem delu poteka evalvacija, kjer učenci razmišljajo o poteku dela in zaključkih, do katerih so prišli. Rezultate predstavijo v obliki tabel in grafov ter pripravijo načrt smiselnosti in potrebe po soljenju cest. Upoštevati morajo zahteve varstva okolja in predvideti vremenske razmere. Učencem omogoča razviti bolj trdno, integrirano, koristno razumevanje konceptov ter njihovih medsebojnih povezav in uporabnost. Poudarek je na razumevanju in ne na golem učenju podatkov ter na sklepanju namesto na podajanju odgovorov.

ZAKLJUČEK

Problemski pristop učencem omogoča boljše poznavanje pomena povezave znanosti z družbenimi vprašanji. Učenci razvijajo kompleksnejši pogled na kemijsko znanost, ne zgolj kot na predmet kemija ampak na vedo, ki je vpeta v naš vsakdan.

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THE DESIGN OF INTERDISCIPLINARY LABORATORY EXERCISES ON CHEMISTRY AND BIOLOGY WITH AN EMPHASIS ON COLLABORATIVE WORK EXPERIMENTAL RESEARCH AND THE NEW CULTURE OF VERIFICATION AND EVALUATION OF KNOWLEDGE / MEDPREDMETNO NAČRTOVANE LABORATORIJSKE VAJE IZ KEMIJE IN BIOLOGIJE S POUDARKOM NA RAZISKOVALNO EKSPERIMENTALNEM SODELOVALNEM DELU IN NOVI KULTURI PREVERJANJA IN OCENJEVANJA ZNANJA

Branka Klemenčič

Šolski center Novo mesto

branka.klemencic@guest.arnes.si

Valentina Mavrič Klenovšek

Šolski center Novo mesto

valentina.mavric@guest.arnes.si

ABSTRACT

According to the revised curriculum, the teaching of science-based subjects is becoming highly integrated by introducing interdisciplinary and team teaching.

Laboratory work in chemistry and biology offers the opportunity for active forms of instruction, which include a new approach of learning and teaching, and thus a new culture verification and evaluation of knowledge. Interdisciplinary work is carried out in a condensed form, where students in groups of 4 deal with experimental properties by using chemical and biological methods. The students of the groups independently plan, implement and present their findings in the form of multimedia presentations and written reports.

Keywords: *team teaching, interdisciplinary teaching, cooperative learning, experimental learning, a new culture of teaching*

UVOD

Za razumevanje izsledkov naravoslovnih znanosti je nujno medpredmetno povezovanje znotraj fizike, kemije in biologije kot tudi z ostalimi predmeti. Poleg uveljavljenih naravoslovnih in projektnih dni lahko tako izvedemo tudi običajne laboratorijske vaje.

Z uvajanjem posodobljenih učnih načrtov se učiteljem kemije in biologije ponuja veliko tem, ki jih lahko s timskim poučevanjem obdelamo v razredu. Bistvo timskega poučevanja je vzajemna povezanost učiteljev, ki si med seboj pomagajo in dopolnjujejo. Tim učiteljev ne predvideva le odnosov med učitelji, ampak tudi med učitelji in učenci. Tovrstno delo je dober zgled dijakom o medsebojnem sodelovanju, saj vsak učitelj vnaša v pouk svoje strokovne in osebnostne posebnosti, po katerih je prepoznaven med učenci, sodelavci in starši. Za timsko poučevanje so še posebej zanimive teme, pri katerih lahko dijaki s sodobnimi oblikami dela osvojijo tako procesne kot vsebinske cilje. Prednost timskega poučevanja je vsekakor sodelovalno načrtovanje in nenehno sodelovanje tako pri izvedbi kot pri vrednotenju dijakovih učnih dosežkov. Za profesorje tovrstno delo zahteva veliko več načrtovanja in fleksibilnosti kot pri klasični izvedbi pouka.

Na Šolskem centru Novo mesto smo si v projektu Posodobitev gimnazije zadali za prioritetno nalogo medpredmetno povezovanje in timsko delo. Ker medpredmetno povezovanje predstavlja didaktični pristop, kjer učitelj poskuša določeno vsebino podati in obravnavati čim bolj celostno, smo si profesorji biologije in kemije zadali cilj pripraviti čim več kakovostnih navodil za izvedbo medpredmetno načrtovanih laboratorijskih vaj. Če upoštevamo, da je znanje paleta veščin in spretnosti ter je pouk usmerjen v načrtno razvijanje teh spretnost in veščin, je treba temu prilagoditi tudi preverjanje in ocenjevanje. Pri pouku kemije in biologije se lahko vrednoti znanje s sposobnostjo reševanja avtentičnih nalog in problemov, ki jih vpeljemo v laboratorijsko delo. Na ta način dijake navajamo na uporabo pridobljenih znanj pri reševanju problemov, s katerimi se soočamo v življenju. Pri spremljanju in vrednotenju znanja lahko vključimo tudi procesne spretnosti, kot so načrtovanje, opazovanje, preizkušanje, interpretiranje in podajanje zaključkov.

METODA

Medpredmetno načrtovane vaje smo izvedli v strjeni obliki po dve ali tri šolske ure s skupino šestnajstih dijakov treh oddelkov prvega letnika tehniške gimnazije. Pri izvedbi smo sodelovali profesorji kemije in biologije. Za izvedbo vaj smo izdelali navodila za laboratorijsko delo, ki vključujejo sodobne oblike pouka, kot so sodelovalno učenje, raziskovalno učenje, delo z viri, uporaba IKT, učenje učenja,… Pri izvedbi laboratorijskih vaj smo težili k temu, da so dijaki šli skozi vse pomembne faze izgrajevanja spoznanj in njihove uporabe. Dijaki so samostojno načrtovali in izvedli enostavne laboratorijske vaje. Pri tem so varno uporabili osnovne znanstvene raziskovalne metode, poiskali relevantne informacije iz različnih virov (elektronskih, pisnih in ustnih) in kritično ovrednotili njihovo zanesljivost. Ugotavljali so skupne značilnosti in razlike, luščili bistvo, sklepali in preizkušali svoje hipoteze. Sledile so razprave in strjevanje zaključkov. Laboratorijske vaje so se zaključile z multimedijskimi predstavitvami.

Največja novost so izdelani opisniki za vrednotenja znanja, ki so dober pripomoček za preverjanje in ocenjevanje znanja tako profesorjem kot dijakom in njihovim staršem. Sestavljeni so tako, da dijaka spremljajo od faze načrtovanja preko izvedbe do zaključka laboratorijskega dela s pripravo poročila in predstavitve vaje ostalim sošolcem.

REZULTATI

Rezultat medpredmetno načrtovanih laboratorijskih vaj so tri interna gradiva pri različnih učnih temah kemije in biologije, ki vključujejo medpredmetno pripravo na pouk, navodila za laboratorijske vaje, opisnike za preverjanje in ocenjevanje znanja ter evalvacijske vprašalnike.

V enem letu smo uspeli oblikovati spletno učilnico za kemijo in biologijo, v kateri so objavljena vsa nastala gradiva. Dijaki so po opravljeni evalvaciji izrazili zadovoljstvo nad tem, da imajo dostopna navodila za laboratorijsko delo, opisnike ocenjevanja, primere poročil skupin dijakov o opravljenih laboratorijskih vajah in multimedijske predstavitve.

Na takšen način razvijamo sposobnost raziskovalnega in kompleksnega razmišljanja, saj določeno snov spoznavajo po kemijskih lastnostih in biološki vlogi v živih sistemih.

ZAKLJUČEK

Po izvedenih evalvacijah in samoevalvacijah ugotavljava, da je sodelovalno raziskovalno delo pri dijakih dobro sprejeto. Dijaki so v enem šolskem letu razvijali ključne kompetence, ki so predvidene z učnim načrtom, saj medpredmetno načrtovane laboratorijske vaje v ospredje postavljajo posameznika, ki preko aktivnih oblik učenja postopoma izgrajuje svoje znanje.

S timskim poučevanjem so dijaki zadovoljni, saj imajo istočasno na voljo učitelja kemije in biologije, ki z zastavljanjem intelektualnih dilem od učencev zahtevata vse bolj poglobljen razmislek.

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PROJECT LEARNING – MAKING OF A GO-CART
/
PROJEKTNO UČENJE – IZDELAVA VOZILA KART

Ivan Klenovšek

Gimnazija Jurija Vege Idrija

ivoklenovsek@yahoo.com

ABSTRACT

Efficiency-orientated society demands that pupils at the end of their technical education are able to think independently, that they are personally initiative and have organizing abilities. Classical school could not realize this task, neither in terms of time or content. That is the reason why we choose the form of educational project work where the contents of at least three regular subjects were connected.

Each pupil had his own field of work, mentors task was to direct and coordinate pupils' work and also to acquire sponsors and ensure equipment, materials and other necessary means.

Project work provides learning from own experience which increases the quality and long term acquired knowledge. That was established and confirmed at graduational examinations and at presentations of our product.

Keywords: *project learning, interdisciplinary correlations, creative ideas, team work, product presentation.*

UVOD

Gokart so izumili zdolgočaseni ameriški piloti, ki so si v prostem času iz kosilnic sestavljali majhne avtomobilčke za dirkanje. Ta njihova zabava se je hitro razvila v zelo zanimiv in popularen šport. Zanimivo je, da sploh nimajo natančno definiranega imena saj jih lahko imenujemo različno (go carts, go karts, shifter cars, supercarts,…)

Vožnja z gokartom je prav posebna izkušnja, občutek imamo kot da bi sedeli v formuli. Stil vožnje je podoben, le da so hitrosti dosti manjše. Veliko dirkačev je svoje kariere začelo prav na gokartu, saj je odličen za učenje osnov dirkanja. Z gokartom dirka tudi veliko amaterjev, ki si želijo preproste adrenalinske zabave na štirih kolesih.

Gokart je poseben tudi zato, ker nima vzmetenja, zato mora biti šasija toliko bolj fleksibilna a obenem dovolj toga da gokart ostane na cesti še posebej v zavojih. Motorji za gokart so 2 in 4 taktni bencinski ali električni. 2 taktni motorji so ponavadi vzeti z motorjev kot so Honda, TM, Stratton ali namensko narejeni tekmovalni motor Rotax, medtem ko so 4 taktni motorji ponavadi standardni motorji kosilnic.

Dijaki so z izdelavo čisto pravega karta uresničili mladostne sanje o dirkanju in hkrati opravili del zrelostnega izpita na svoji izobraževalni poti.

METODA

V projektu smo takoj opazili možnost, da dijaki povežejo znanja, pridobljena pri različnih predmetih med šolanjem in jih združijo v snovanju, izdelavi, montaži, preizkušanju in predstavitvi celovitega izdelka.

Področje motornih vozil je dijakom relativno blizu in jih privlači. Ker pa je izdelava takega vozila povezana z učno snovjo njihovega izobraževanja, je bila odločitev za tak izziv še toliko lažja in s strani maturitetne komisije brez pomislekov potrjena. Pri realizaciji takega projekta dijaki pridobivajo izkušnje, znanje, spretnosti in sposobnosti, oblikujejo se osebnostne lastnosti, torej se vsestransko in celostno razvijajo.

Z izdelavo takega vozila so dijaki pobližje spoznali projektno učno delo, se naučili dela v skupini ter uresničili sanje mnogih profesorjev – mentorjev po uvedbi take oblike dela, ki omogočajo medpredmetne povezave v večji meri kot pri ostalih učnih metodah klasičnega pouka.

REZULTATI

Dijaki so delali ob prostem času, popoldan in od koncu tedna. Glavni nosilec aktivnosti v vseh etapah je dijak sam, učitelj pa je pobudnik in svetovalec. Kot mentor sem dijakom pomagal navezovati stike s sponzorji, ki so nam pomagali z določenimi deli in materialom, pa tudi s storivami na strojih, ki jih v šoli nimamo na razpolago.

Dijaki si lahko v okviru 4. izpitne enote poklicne mature sami izberejo temo in naslov naloge. Dijaki skupaj z mentorjem dokončno izoblikujejo idejo ter pripravijo načrt za uresničitev ideje, ves potreben material in pripomočke.

Delo je potekalo po fazah, kot je prikazano v nadaljevanju.

Po končanem sestavljanju izdelka in njegovem funkcionalnem preizkusu je sledil zagovor pred šolsko maturitetno komisijo, kjer so predstavili potek dela po posameznih zadolžitvah in fazah izdelave.

Komisija je bila z zagovorom zadovoljna in njihov izdelek ocenila z najvišjo možno oceno.

V naslednjih dneh je sledilo še nekaj predstavitev njihovega dela sošolcem, osnovnošolcem, staršem in ostalim zainteresiranim ter predstavnikom sedme sile, ki so pripravili zanimive članke in radijske oddaje.

Slika 1: Načrtovanje vozila   Slika 2: Izdelava podvozja

Slika 3: Sestavljanje vozila   Slika 4: Predstavitev vozila

ZAKLJUČEK

Po zaključku projekta lahko ugotovimo, da je bilo delo dijakov uspešno. Dosegli so večino učnih ciljev, zadanih na začetku šolanja med katerimi moramo poudariti sposobnost za samostojno razmišljanje in delo, sodelovanje v skupini in ne nazadnje realizacujo generiranih idej.

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KEYTONATURE PROJECT AND USE OF INTERACTIVE IDENTIFICATION TOOLS AT CLASS OF NATURAL SCIENCE AND OF BIOLOGY IN SLOVENIA / PROJEKT KEYTONATURE TER UPORABA INTERAKTIVNIH DOLOČEVALNIH KLJUČEV PRI POUKU NARAVOSLOVJA IN BIOLOGIJE V SLOVENIJI

Irena Kodele Krašna

Prirodoslovni muzej Slovenije

irena.kodele-krasna@guest.arnes.si

ABSTRACT

The aim of this paper is to present some of the results of testing of new interactive e-tools for learning and teaching biodiversity which were developed in ongoing eContentplus European project KeyToNature. These interactive identification tools are tailored to the needs of different educational users. We found out that identification of organisms with these tools is not easy only for students but also for primary schools pupils who just learned to read.

Keywords: *KeyToNature, identification tools, biodiversity*

UVOD

KeyToNature - KljučDoNarave je triletni ciljni evropski projekt v okviru programa eContentplus, ki poteka v enajstih državah Evropske skupnosti, vanj pa je vključenih štirinajst vodilnih evropskih ustanov s področja biologije, vzgoje in izobraževanja ter informacijske tehnologije. Namen projekta je oblikovanje takih interaktivnih določevalnih orodij, ki jih bodo pri spoznavanju biotske pestrosti učinkovito uporabljali osnovnošolci, srednješolci in študentje širom Evrope. Prednosti novih interaktivnih določevalnih orodij pred klasičnimi določevalnimi ključi je predvsem v njihovi prilagodljivosti potrebam učiteljev in sposobnostim učencev.

Začetni fazi projekta, v kateri se je ugotavljalo potrebe po določevalnih orodjih pri pouku in izdelalo prve interaktivne določevalne ključe, je sledilo testiranje le-teh v evropskih izobraževalnih ustanovah vseh nivojev od osnovnih šol do univerz. Poleg izobraževalnih seminarjev, na katerih smo učiteljem predstavili nova določevalna orodja, možnosti njihove uporabe in prilagajanja za potrebe pouka, smo izvedli tudi več osebnih svetovanj učiteljem. Do sedaj je bilo v slovenskem jeziku narejenih preko 50 določevalnih orodij, vsa pa so prosto dostopna preko spleta in učitelji jih vedno pogosteje uporabljajo. Na podlagi odzivov učiteljev se določevalna orodja nadgrajuje in izpopolnjuje, vzporedno pa se razvija tudi možne scenarije njihove uporabe.

METODA

Nova interaktivna določevalna orodja smo testirali v osnovnih in srednjih šolah po Sloveniji. Učitelje smo vabili k sodelovanju preko medijev in na srečanjih študijskih skupin. Analizo uporabnosti določevalnih orodij smo naredili na podlagi izpolnjenih anketnih vprašalnikov, ki so nam jih poslali učitelji. Testiranja na predmetni stopnji osnovne šole in v srednjih šolah so izvedli učitelji sami, testiranja na razredni stopnji osnovne šole pa so potekala ob pomoči biologa – sodelavca projekta KeyToNature iz Prirodoslovnega muzeja Slovenije. Uporabnost določevalnih orodij smo testirali v različnih okoljih – v računalniški učilnici in na terenu, kjer smo uporabili prenosne računalnike in mobilne telefone. V primeru večjih skupin (preko 40 učencev) smo uporabili natisnjeno obliko določevalnega ključa. Učenci nižjih razredov osnovne šole so uporabili manjše, njim prilagojene določevalne ključe (npr. Ključ za določanje rastlin na travniku pred šolo v Budanjah).

REZULTATI

Izpolnjene anketne vprašalnike nam je vrnilo 19 učiteljev, od tega 5 učiteljev razredne stopnje in 12 učiteljev predmetne stopnje osnovne šole ter 2 gimnazijska učitelja. Skupno je v testiranjih sodelovalo 710 učencev in dijakov. Največkrat uporabljeni določevalni ključ je bil Interaktivni vodnik za določanje lesnatih rastlin Slovenije (31%), v 5-ih primerih (26%) pa so učenci delali s ključem, ki je bil narejen za točno določeno šolo. Uporabili smo predvsem dihotomne določevalne ključe (90%), saj ključi s kompleksnim pristopom zahtevajo od učencev več predznanja in izkušenj.

Interaktivni določevalni ključi so se izkazali kot zelo uporaben pripomoček tako pri rednem pouku kot pri izvedbi naravoslovnih oz. tehničnih dni ter interesnih dejavnosti. Po kratki predstavitvi dela z določevalnimi ključi in razlagi osnovnih pojmov, ki so v ključih uporabljeni, so z njimi samostojno določali organizme tudi učenci prve in druge triade osnovne šole. Ob delu z določevalnimi ključi so učenci spoznavali rastline in živali značilne za določeno življenjsko okolje (travnik, gozd, potok…), spoznavali zgradbo rastlin oz. živali, razvrščali rastline v sistem, razvijali so funkcionalno rabo branja, vadili sodelovalno in samostojno učenje… Vsi učitelji, ki so sodelovali v anketi, bi dejavnost, pri kateri so uporabili določevalne ključe, še ponovili. Učencem je bilo pri teh dejavnostih všeč predvsem to, da so bili aktivni in samostojni pri delu. Dejavnosti so se izkazale za uspešne ne glede na to, katera oblika ključa je bila uporabljena (interaktivni ključi na računalnikih ali natisnjeni na papir) in kje je dejavnost potekala (v učilnici ali na prostem) (Slika 1). Velika večina (80%) učiteljev meni, da se je po izvedeni dejavnosti z določevalnimi ključi zanimanje učencev za biotsko pestrost zelo povečalo.

Slika 1: Uporaba KeyToNature določevalnih ključev (a – učenci razredne stopnje osnovne šole z natisnjeno obliko ključa, b – učenci predmetne stopnje osnovne šole z interaktivnim določevalnim ključem na računalniku, c – gimnazijka z interaktivnim določevalnim ključem z dostopom do baze fotografij preko spleta)

ZAKLJUČEK

Ugotovili smo, da so nova določevalna orodja zelo primerna za samostojno ali skupinsko delo učencev, da omogočajo diferenciacijo pouka na enostaven način, da jih učenci z veseljem uporabljajo in da ne pomenijo samo popestritev pouka, ampak da je z njimi doseganje zastavljenih učnih in vzgojnih ciljev lažje, znanje pa trajnejše.

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PROJECT DAYS IN THE UPPER IDRIJCA REGIONAL PARK
/
PROJEKTNI DNEVI V KRAJINSKEM PARKU ZGORNJA IDRIJCA

Romana Kokošar

Gimnazija Jurija Vege Idrija

romanakokosar@gmail.com

ABSTRACT

The project days involve two mainly science projects where the students practise experimental and field work. In the first project they work in groups where they either research chemical and geological ground composition and study vegetation, or they use the bicycle to get to different points where the measurements are done and later the tables designed. The final result is a brochure that includes the bicycle-path map and its description. The second project is based on interdisciplinary connection of three science subjects pursuing each its own aim and also one common aim – determination of the biotic index of the river.

Keywords: *regional park, field work, authentic learning, bicycle-path map, biotic index of a river.*

UVOD

Predstavila bom dva pretežno naravoslovna projekta, ki ju izvajamo v prvem oz. drugem letniku gimnazijskega programa in ju povezuje skupen prostor raziskovanja: Krajinski park Zgornja Idrijca. Ta prostor je bil izbran zaradi potrebe in želje, da učenci, ki obiskujejo našo šolo, spoznajo naravne in kulturne znamenitosti tega krajinskega parka, ki nosi izredno težo in pomen za idrijsko občino.

METODA

Prvi od obeh projektov se izvaja **v prvem evropskem oddelku**. Interdisciplinarno se poveže več naravoslovnih predmetov, sodelujejo pa tudi učitelji predmetov informatike, slovenščine, umetnostne vzgoje in športne vzgoje. Dijaki se že prej odločijo za sodelovanje v eni od treh skupin. Prva skupina na izbranem območju parka raziskuje kemijsko in geološko strukturo tal ter proučuje vodilne rastlinske vrste oz. živali v podrasti in na drevesih. Druga skupina opravi določen del poti s kolesi in meri nadmorske višine, prevoženo pot in čas vožnje, nato smiselno oblikuje tabele, vanje vnaša meritve, izračuna strmino klanca. Tretja skupina se seznani z delovanjem klavž in pomenom tega tehniškega spomenika v idrijski preteklosti, nato pa fotografira posamezne motive na terenu, v šoli pa fotografije računalniško obdela in ustvari fotostrip. Za našo predstavitev bi se podrobneje ustavili pri metodi dela prvih dveh skupin.

V prvi skupini se medpredmetno povežejo kemija, biologija in geografija.

Pri kemiji izvajajo terensko delo: izkopljejo talni profil, določijo horizonte in v vsakem izmed njih s pomočjo kovčka za analizo tal in vode določijo teksturo, obstojnost strukturnih agregatov, prekoreninjenost, barvo, vonj, reakcijo tal, proste karbonate, vsebnost dušika, fosforja. Na podlagi vseh analiz določijo vrsto tal in predvidijo lastnosti tal: zračnost, prepustnost za vodo, vsebnost hranil.

Pri biologiji in geografiji raziskujejo geološko sestavo tal, prepoznavajo značilnosti kamnin in ocenijo površino jezera in dolžino Jezernice; pobirajo in proučujejo živali v podrasti in na drevesih ter nabirajo posamezne vodilne rastlinske vrste in jih poimenujejo; po delu v laboratoriju dokumentirajo, urejajo in klasificirajo.

V drugi skupini se medpredmetno povežejo športna vzgoja, matematika in fizika. Učenci morajo s kolesi opraviti krožno kolesarsko pot in na kontrolnih točkah opravljati meritve. Merijo nadmorske višine, prevoženo pot in čas vožnje ter zapisujejo podatke. Nato v šoli oblikujejo tabele in vanje vnašajo meritve. Računajo povprečne hitrosti na posameznih odsekih poti, rišejo prerez prevožene poti in graf povprečne hitrosti v odvisnosti od prevožene poti.

Drugi od obeh projektov temelji na interdisciplinarni povezavi treh naravoslovnih predmetov, ki so si zastavili skupen cilj, hkrati pa sledijo svojim internim ciljem.

Pri biologiji dijaki s pomočjo vodnih mrež nabirajo vzorce vzdolž rečnega toka. Nabrani material orientacijsko določijo s pomočjo določevalnih ključev. Rezultate vpišejo v delovne liste in s pomočjo tabel o vrstah in številu indikatorskih organizmov ter z rezultati kemijskih in fizikalnih meritev predvidijo kvaliteto vode v raziskovani reki. V okviru fizike dijaki pri pouku s pomočjo fizikalnih zvez, ki jih že poznajo, izpeljejo enačbo za masni pretok. Enačbo za potencialno energijo in moč rečnega toka izrazijo z masnim pretokom. Iščejo rešitve za izmero vseh parametrov za določitev masnega pretoka.

V krajinskem parku merijo hitrost rečnega toka in njegov presek. S pomočjo delovnih listov računajo pretok in energetski potencial zgornjega toka Idrijce ter ga primerjajo z močjo HE Mrzla Rupa. S položnic za dobavo elekrične energije računajo povprečno moč, ki jo troši posamezno gospodinjstvo. Izračunajo število gospodinjstev, ki ga lahko oskrbuje HE Mrzla Rupa, in tako ovrednotijo vlogo malih HE pri varovanju okolja. Pri kemiji pred odhodom na teren odvzamejo vzorec onesnažene vode reke Idrijce v mestu, nato pa še vzorec domnevno čiste vode v Krajinskem parku. Oba vzorca analizirajo s pomočjo analiznega kovčka. Prepoznavajo in podajajo opise organoleptičnih lastnosti vzorcev. Dobljene rezultate vnašajo v popisni list za kemijsko analizo vode in ga dopolnijo s temperaturo vode, ki so jo izmerili pri biologiji

REZULTATI

Izpostavimo najprej rezultate projekta, ki se izvaja v 1. evropskem oddelku. V okviru kemije na podlagi vseh analiz določijo vrsto tal in predvidijo lastnosti tal.

Pri biologiji in geografiji opravijo izbor posameznih vodilnih rastlinskih vrst in obdelajo značilnosti ter

predstavijo botanične in geološke značilnosti Divjega jezera. V kolesarski skupini, kjer igrata glavno vlogo matematika in fizika, grafično ponazorijo prevoženo kolesarsko pot in izdelajo zgibanko za potrebe turistične ponudbe v kraju.

Rezultati drugega projekta, ki združuje biologijo, kemijo in fiziko ter poteka v drugem letniku, pa, kot že omenjeno, zadostijo tako internim ciljem posameznih predmetov kot skupnim ciljem. Pri predmetu biologije je cilj dosežen, ko dijaki zgornji tok reke Idrijce prepoznajo kot ekosistem in ko znajo določiti BI (biotski indeks) reke. Pri fiziki dijaki določijo energijski potencial Idrijce v zgornjem toku s pomočjo masnega pretoka in ovrednotijo izračunano vrednost. Pomemben je tudi odgovor na vprašanje, kakšna je vrednost malih HE za elektroenergetski sistem. Pri kemiji pa dijaki opišejo organoleptične lastnosti vode in spoznajo ter izvedejo metodo kemijske analize vode.

Končni rezultat pa je seveda vrednotenje dobljenih rezultatov oz. določanje biotskega indeksa reke. Pomembno je tudi kompleksno strokovno poročilo, v katerem morajo dijaki odgovoriti na vprašanje, s katerimi rezultati meritev so se približali globalni sliki stanja reke Idrijce.

ZAKLJUČEK

Tako pri prvem kot pri drugem projektu so bili povezovalni elementi delo na terenu ter didaktične metode in postopki, ki so temeljili na avtentičnem učenju.

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DIDACTIC GAMES IN CHEMISTRY LESSONS
/
DIDAKTIČNE IGRE PRI POUKU KEMIJE

Jasmina Kolbl

OŠ Radenci

jasmina.kolbl@guest.arnes.si

ABSTRACT

It is almost impossible to imagine teaching chemistry without experimental work. However, using experimental work in some chapters can be almost impossible. Therefore teachers use and help ourselves with didactic games. In this way learners are able to acknowledge the field of reaction chemistry and get excited over chemistry, develop logical thinking and realize, that chemistry is not a dull science and that you can enjoy solving chemistry exercises, get to think and except chemistry in a different way. In the following contribution the didactic games, appropriate for chemistry lessons, are presented in detail.

Keywords: *motivation, didactic games, chemistry.*

UVOD

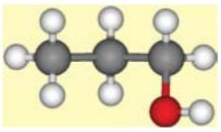
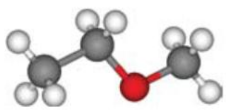
Ob spoznanju, da je dejanska sprostitev v razvoju in življenju današnjega človeka nepogrešljiva, z didaktičnimi igrami učencem omogočimo, da menjajo svojo obvezno obremenjujočo dejavnost z rekreativnimi in sprostitvenimi dejavnostmi. Skozi igro učenci urijo motorične spretnosti, hitrost odzivanja, usklajenost vida in gibanja, zavedanje lastnega telesa, vidno, slušno in tipno zaznavanje. Čeprav so didaktične igre, ki sem jih izbrala, namenjene uporabi pri pouku kemije, pa obenem učenci razvijajo govor, bogatijo besedišče in širijo splošno poučenost.

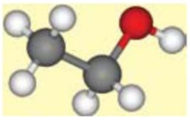
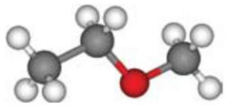
METODA

Za izdelavo kvalitetnih didaktičnih iger potrebujemo veliko slikovnega gradiva, ki ga je pogosto treba še oblikovati. Delo z računalnikom je torej neizogibno. Za daljšo življenjsko dobo didaktičnih iger (predvsem letakov in drugih, natisnjenih na papir) je le-te dobro plastificirati. Vendar dandanes ob uporabi tehnologije (elektronska tabla v povezavi z računalnikom) lahko pripravimo didaktične igre kar v ustreznem računalniškem programu in se izognemo preveliki porabi papirja in ostalih pripomočkov.

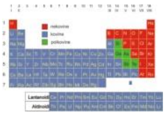
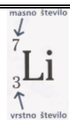
REZULTATI

Primeri didaktičnih iger: Spomin (Organske kisikove spojine, 9.r), Domine (PSE, 8.r) in Tombola (Splošna in organska kemija, 8.r).

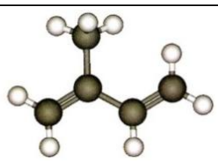
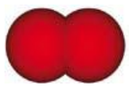
	propanol		etil metil eter

propan-2-ol		Dimetil eter	

Primer didaktične igre 1: Spomin

	V PS so elementi razvrščeni v Ž	skupine in periode.	Elementi so razvrščeni v skupine glede na L
število elektronov v zunanji lupini	ter v periode, v katerih se A	veča število elektronov v isti lupini.	Elementi v isti skupini imajo H
podobne kemijske lastnosti.	Elektrone zunanje lupine v atomu imenujemo T	valenčni elektroni.	Elementi so v PS po skupinah razvrščeni v N
navpične stolpce,	po periodah pa v I	vodoravne vrste.	Poleg 8 glavnih skupin PS posebno mesto v PS zavzemajo še P
stranske skupine (prehodni elementi),	pri katerih se z naraščajočim vrstnim številom polnijo L	orbitale d.	Več kot ¾ elementov so I
kovine s posebnimi fizikalnimi in kemijskimi lastnostmi.	Preostalo so N	nekovine, polkovine in žlahtni plini.	 I

Primer didaktične igre 2: Domine

Primer didaktične igre 3: Tombola

ZAKLJUČEK

Pogoj za uspešno delo pri uporabi didaktičnih iger je, da ima učitelj pripravljene zbirke iger z navodili za uporabo. Še posebej moramo upoštevati načelo podajanja navodil. Ta morajo biti jasna in razumljiva vsem otrokom. V sproščenem in ustvarjalnem ozračju sta potem zadovoljna oba: učitelj in učenec.

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THE PLANT PROTECTION PRODUCTS BY THE METHOD OF PROJECT COOPERATIVE WORK
/
FITOFARMACEVTSKA SREDSTVA Z METODO PROJEKTNO SODELOVALNEGA DELA

Stana Kovač Hace

Srednja šola Zagorje

kovachace@gmail.com

ABSTRACT

At the Secondary school Zagorje we often perform project cooperative work which includes some professors and all students of a class. The topic Plant Protection Products is presented by the method of project cooperative work. The set goals were accomplished in the following subjects: Chemistry in Profession (Health care, open curriculum), Slovenian, English, Health care and Professional terminology (Latin). The emphasis was on active methods and forms of work. This type of work enabled students to develop different competences (ICT, learning to learn, social skills) as well as opportunities for cooperative work and the competence of health protection.

Keywords: *project cooperative work, active methods, integrated competences*

UVOD

Na šoli tretje leto izvajamo prenovljene programe, zato v svoje delo oziroma v delo dijakov vključujemo nove metode dela, kot so projektno–sodelovalno delo, medpredmetne integracije, projektni dnevi, kamor vključujemo tudi integrirane kompetence.

V prispevku bo predstavljen primer medpredmetnega pristopa pri obravnavi tematskega sklopa Fitofarmacevtska sredstva z metodo projektno sodelovalnega dela. Dijaki so pri tem realizirali cilje predmetov: kemija v stroki (zdravstvena nega, odprti kurikul), slovenščina, angleščina, zdravstvena nega in strokovna terminologija (latinščina).

Pri projektno–sodelovalnem delu je bil poudarek na aktivnih metodah in oblikah dela. V ospredju je bila vloga kemije za zdravje, varnost in okolje. Pri delu so dijaki eksperimentirali, analizirali, pisali zaključke, argumentirali ter bili sposobni vključevati refleksijo o svojih dosežkih. S takšnim delom so dijaki osvojili kemijske pojme na primerih, ki se navezujejo na njihov poklic, prav tako pa so razvijali poklicne kompetence. S takšnim načinom dela se pri dijakih poveča razumevanje kemijskih pojmov. Cilj takšnega načina dela je, da so dijaki sposobni združiti znanje različnih področij, predvsem s poklicnim delom. Takšno znanje je osnova za razumevanje in nadgradnjo strokovno-teoretičnih predmetov ter za vseživljenjsko učenje.

Dijaki so pri tem načinu dela razvijali tudi IKT kompetenco, kompetenco učenje učenje, kompetenco socialnih veščin – razvijajo zmožnosti za sodelovalno delo ter kompetenco varovanja zdravja.

Profesorice šestih predmetov smo se povezale v projektno delo, izdelale skupno pripravo ter načrt dela, pri tem je bila kemija v stroki nosilni predmet.

METODA

Profesorice smo izdelale skupno pripravo in načrt dela. Prvo uro smo dijakom predstavile pravila, dijake razdelile v sedem skupin, v sklopu katere je vsaka dobila svojo temo, natančna navodila o poteku dela in pričakovanem izdelku oz. rezultatu dela (PPT predstavitev, film, v katerem so zajeti zaključki, ugotovitve, komentarji ter predstavitve, potek in rezultat eksperimentalnega dela). V naslednjih osmih urah so dijaki sami pripravili načrt dela, s katerim so določili zadolžitve posameznim članom skupine. Člani so v skupini predlagali ideje, zbirali ustrezno literaturo ter sestavili in oblikovali izdelek, ki so ga oddali profesoricam v pregled. Zadnji dve uri je sledila predstavitev dela skupin učiteljskemu zboru. Projekt je potekal štirinajst dni pri vseh predmetih, ki so sodelovali pri projektno-sodelovalnem delu.

REZULTATI

Po predstavitvi smo napravili evalvacijo, kjer smo naprej ocenjevale profesorice, sledilo pa je še samoocenjevanje dijakov (ocenjevalna lista sta bila identična). Primerjale smo število točk dijakov s številom točk profesoric. Ocenjevali smo področja: informiranje, reševanje problemov, podjetnost, komunikativnost in samoorganiziranost.

Primerjava ocene dijakov z ocenami profesoric je pokazala, da se dijaki, ki so pri pouku uspešnejši, ocenjujejo slabše, so do sebe bolj kritični in manj samozavestni, kot dijaki, ki so pri pouku manj uspešni. Izziv profesorjev je, da motiviramo in spodbujamo dijake, ki so zelo kritični do sebe, da v času šolanja postanejo samozavestni in zaupajo vase. Tisti dijaki, ki so premalo samokritični, pa morajo v času šolanja priti do spoznanja, da le veliko truda in treninga vodi do želenih rezultatov.

Izkušnje takšnega načina dela kažejo, da so dijaki bolj motivirani za delo, tudi znanje, ki sem ga ocenjevala na pisnem preverjanju, je bilo boljše.

ZAKLJUČEK

Ugotavljam, da je takšen način dela za dijake smiselen, saj dijaki dosegajo boljše rezultate. Pri pouku so aktivni, med seboj komunicirajo, se naučijo poslušati ostale v skupini, delijo svoje mnenje z drugimi, razvijajo spretnosti predstavljanja svojega dela ter so sposobni kritičnega vrednotenja svojega dela ter dela drugih. Izkušnje so pozitivne, zato bomo s takšnim delom na šoli nadaljevali.

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USAGE OF ELECTRONIC LITERATURE AND INFORMATIONAL COMMUNICATIVE TECHNOLOGY(ICT) AT CHEMISTRY CLASSES
/
UPORABA E-GRADIV IN IKT TEHNOLOGIJE PRI POUKU KEMIJE

Karmen Krašna Otrin

Šolski center Rudolfa Maistra Kamnik

karmen.krasna@guest.arnes.si

ABSTRACT

With the help of electronic literature, ICT and interactive blackboard, we managed to get across learning unit ˝Constant of acids and bases˝. The preparation and realization of lessons were held in a slightly different, a little more extraordinary way as usual. One of the lessons was held in computer classroom, and the second lesson in a specialized classroom with electronic interactive blackboard. During the first lesson, students had to solve a few tasks from electronic literature. During this lesson their notebooks were not required, but it did require a more comprehensive preparation for the teacher. Electronic literature matches with the existent learning program quite well and it is also preferred by the students.

I also used this e-literature for teaching new chapters in learning unit ˝Constant of acids and bases˝, at which I had to take into consideration the students' previous knowledge, which they had acquired in the chapter ˝Balance in water solutions˝. During the third lesson, students had to find some animations, in connection with the current learning unit, on the internet. Each of them than had to prepare at least two questions, which were then used in power point presentation.

Keywords: *interactive blackboard, constant of acids and bases, electronic literature*

UVOD

V svoji predstavitvi bom podrobno opisala pripravo in izvedbo treh učnih ur z uporabo e-gradiv in IKT tehnologije. Tema je bila izbrana iz poglavja »Ravnotežje v vodnih raztopinah«, učna enota pa je »Konstanta kislin in baz«.

METODA

Pri izvedbi treh učnih enot z uporabo e-gradiv bi poudarila aktivno vlogo dijakov kot tudi učitelja. Dijaki so v prvi uri v računalniški učilnici reševali probleme iz e-gradiv v okviru ponovitve predhodne snovi. Druga ura je potekala v učilnici za kemijo z interaktivno tablo, pri čemer so dijaki aktivno sodelovali. Uporabila sem program PowerPoint 2003 na interaktivni tabli, kjer sem opombe in komentarje sproti vnašala z elektronskim pisalom. Iz slikovnega gradiva (mikro nivo) smo razvrstili kisline in baze na močne in šibke. Jakost kislin in baz smo določili s pomočjo vrednosti K_a in K_b. Pomagali smo si s stolpičasto in grafično animacijo v gradivu. Zapisali smo razlike med močnimi in šibkimi elektroliti, naučili smo se zapisa za konstanto K_a in K_b.ter stopnjo protolize šibkih kislin in baz. Tretja ura je potekala ponovno v računalniški učilnici. Delo je potekalo v dvojicah. Vsak par je pripravil dve vprašanji in jih predstavil v PowerPoint-u.

REZULTATI

Ta način dela zahteva nenehno spremljanje dijakove aktivnosti, kajti le tako se lahko ugotovi, če dijaki vsebino razumejo. Pri tem mislim na del, ki poteka v računalniški učilnici. Učna enota »Konstanta kislin in baz« je s pomočjo e-gradiva in interaktivne table bolj nazorna in razumljiva ter bolje pojasni običajno težko predstavljive pojme. Dijakom je ta način dela blizu in to lahko počnejo tudi doma.

ZAKLJUČEK

Delo z računalnikom je bilo za dijake zanimivo in prijazno. Za učitelja pomeni to večjo aktivnost v šoli in tudi doma. Pomanjkljivo pa je to,da računalniške učilnice niso vedno na razpolago. V bodoče bi lahko razmišljali o medpredmetni povezavi kemija – informatika, ali pa o dodatni opremljenosti učilnic za kemijo. Vsi dijaki pa niso enako motivirani, zato nekateri ne sodelujejo. Za večino dijakov pa je bil ta način dela zanimiv in rekli so da je napreden. Pri izvajanju pouka je potrebno biti precej inovativen, da motiviraš čim večje število dijakov.

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COOPERATIVE PROJECT WORK IN CHEMISTRY CLASSES AT SECONDARY SCHOOL LEVEL / SODELOVALNOPROJEKTNO DELO PRI POUKU KEMIJE V GIMNAZIJI

Darja Kravanja

II. gimnazija Maribor

darja.kravanja@gmail.com

ABSRTACT

In today's fast changing world it is very important that pupils at schools develop abilities for responsible and active cooperation in problem solving. This can be achieved with the method of cooperative project work which was introduced in chemistry classes at secondary school level as an integral part of the learning process. This article deals with the introduction of cooperative project work in chemistry classes based on three units in three school years. In developing cooperative project work the role of a teacher as a planner of challenging tasks and monitoring the work is also shown as well as different methods of evaluation of pupils' work and their products.

Keywords: *cooperative project work, chemistry, secondary school*

UVOD

V času hitrih sprememb na vseh področjih življenja so tudi zahteve po znanju različnih vsebin in veščin drugačne. Naloga šole je, da učence pripravi na življenje v takem svetu, zato se je pojavila potreba po spremembi učnih načrtov.

V gimnazijskem programu ima kemija vlogo splošnoizobraževalnega predmeta, ki temelji na problemsko naravnanem pouku in raziskovalnem pristopu. Poleg razvijanja naravoslovno-matematične kompetence morajo dijaki razvijati odnosne in odločitvene zmožnosti, kot je sposobnost za odgovorno in aktivno sodelovanje pri razreševanju problemov. To pa lahko razvijamo v obliki sodelovalnoprojektnega dela, ki smo ga začeli uvajati s posodobljenim učnim načrtom.

METODA

Uvajanje sodelovalnoprojektnega dela je prikazano kot metoda učenja pri pouku kemije oziroma kot proces pri treh učnih sklopih skozi tri šolska leta.

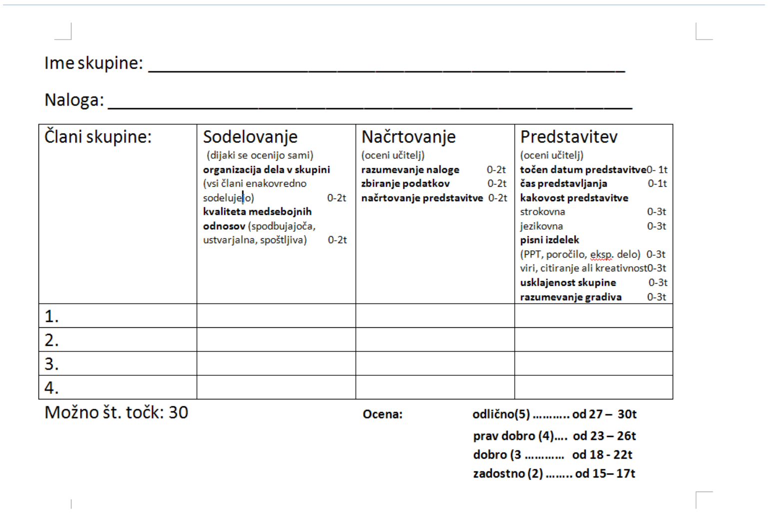
Prvo leto je namenjeno spoznavanju sodelovalnega pristopa pri učnem sklopu Alkalijske kovine in halogeni. Za delo je predvidenih 8 ur. Prva ura je namenjena tvorjenju skupin in spoznavanju načina dela skupine, izgrajevanju zaupanja in povezanosti v skupini s pomočjo različnih didaktičnih iger. Sledi aktualizacija teme z motivacijskimi članki in delovnimi listi, nato pa usvajanje s samostojnim delom skupin. Delo se zaključi z utrjevanjem in preverjanjem znanja ob poročanju skupin ter z demonstracijskim prikazom eksperimentov. Gre za vodeno pripravo na projektno delo, s katerim se srečajo naslednje šolsko leto. Dijaki v skupinah s pomočjo pripravljenih gradiv in skozi različne aktivnosti usvojijo cilje zapisane v učnem načrtu. Učitelj ima pri sodelovalnem delu vlogo organizatorja, povezovalca in kritičnega opazovalca. Skrbno mora pripraviti gradivo, da doseže vse zastavljene cilje v predvidenem času. Dijake mora tudi seznaniti z načinom vrednotenja njihovega dela in znanja. Del odgovornosti pri ocenjevanju nosijo tudi dijaki sami, ki ovrednotijo sodelovanje v skupini – organizacijo dela v skupini in medsebojne odnose (približno 5 % pridobljene ocene.) Učitelj pa oceni načrtovanje in predstavitev skupin oz. posameznih članov skupine.

V drugem letu se dijaki soočijo s sodelovalnoprojektnim delom pri učnem sklopu Lastnosti izbranih elementov in spojin v bioloških sistemih ter sodobnih tehnologijah. Dijaki morajo v sodelovanju rešiti preproste probleme iz vsakdanjega življenja. Primeri: Pridobivanje pomembnih kovin in rud, Uporaba anorganskih spojin v življenju oz. Elementi in njihove spojine v modernih tehnologijah. Sklopu je namenjenih 10 ur od predstavitve pričakovanih dosežkov, preko samostojnega iskanja informacij, samostojnega načrtovanja laboratorijskega dela, do javne predstavitve dela in ocenjevanja izdelkov dijakov. Učitelj mora skrbno pripraviti uravnotežene problemske naloge in izdelati načrt za ocenjevanje izdelkov, organizacijo in načrtovanje dela ter del odgovornosti za ocenjevanje pa prepusti dijakom.

Tretje leto dijaki utrjujejo svoja znanja in veščine o zgradbi in lastnosti izbranih organskih spojin na ta način, da dobijo kompleksni problem, ki ga morajo skupaj razrešiti. Pri tem si morajo sami razdeliti delo, tako da vsak posameznik enakovredno prispeva k rešitvi problema. Čas pouka je namenjen zgolj predstavitvi dela in izdelkov ter ocenjevanju izdelkov. Primer takšnega razrednega projekta je Priprava zdravega obroka (spoznati sestavine, zdravilne učinkovine, dokazovanje teh snovi, energetska vrednost …).

REZULTATI

Izdelani so bili učni listi, motivacijski članki, navodila za laboratorijske vaje in didaktične igre za sodelovalno delo pri proučevanju lastnosti in nahajališč alkalijskih kovin in halogenov v vsakdanjem življenju, prav tako je bil izdelan obrazec za ocenjevanje.


Ime skupine: ______________________________

Naloga: ______________________________

Člani skupine:	Sodelovanje (dijaki se ocenijo sami) **organizacija dela v skupini** (vsi člani enakovredno sodelujejo) 0-2t **kvaliteta medsebojnih odnosov** (spodbujajoča, ustvarjalna, spoštljiva) 0-2t	Načrtovanje (oceni učitelj) **razumevanje naloge** 0-2t **zbiranje podatkov** 0-2t **načrtovanje predstavitve** 0-2t	Predstavitev (oceni učitelj) **točen datum predstavitve** 0- 1t **čas predstavljanja** 0-1t **kakovost predstavitve** strokovna 0-3t jezikovna 0-3t **pisni izdelek** (PPT, poročilo, eksp. delo) 0-3t viri, citiranje ali kreativnost 0-3t **usklajenost skupine** 0-3t **razumevanje gradiva** 0-3t
1.			
2.			
3.			
4.			

Možno št. točk: 30

Ocena: **odlično(5) ……….. od 27 – 30t**
prav dobro (4)…. od 23 – 26t
dobro (3 ………… od 18 - 22t
zadostno (2) …….. od 15– 17t

Slika 1: Ocenjevalni obrazec

Izdelane so bile problemske naloge z navodili in projektna naloga z navodili Opravljena je bila tudi evalvacija znanja dijakov, ki je pokazala, da so dijaki s sodelovalnoprojektnim delom nadgradili svoja znanja, ki so jih pridobili pri obravnavanju drugih učnih sklopov. Bolje razumejo soodvisnost zgradbe, lastnosti in uporabe snovi ter razumejo naravne procese. Na primerih dokazujejo, da so sposobni samostojno načrtovati eksperimentalno delo, poiskati, obdelati in kritično vrednotiti zbrane informacije, uporabljati strokovno kemijsko terminologijo ter reševati preproste oz. kompleksne probleme iz vsakdanjega življenja. Z javno predstavitvijo svojega dela dokazujejo medosebno kompetenco in veščine javnega nastopanja.

ZAKLJUČEK

Sodelovalno projektno delo pripelje do kakovostnejšega znanja dijakov. To pa ne pomeni tudi znanja več informacij, ker so le-te lahko že zastarele, ko zapustijo šolo. Pomeni, da se dijaki naučijo strategij in postopkov za reševanje problemov z veščinami, ki se nanašajo na miselne procese, naučijo se iskanja novih informacij, analize, sinteze in vrednotenja, ob enem pa razvijajo odnosne in odločitvene zmožnosti.

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Načrt dela aktiva kemikov II. gimnazije v šol. letu 2009/10

Posodobljen učnI načrt, Kemija - gimnazija

AN EXAMPLE OF EMPIRICAL LEARNING IN RECOGNIZING THE CARAUSIUS MOROSUS / PRIMER IZKUSTVENEGA UČENJA OB SPOZNAVANJU PALIČNJAKA

Irena Kresevič

OŠ Rudolfa Ukoviča Podgrad

ikresevic@gmail.com

ABSTRACT

The article presents an example of empirical learning in the science field. The author of the article performed the project with the second grade pupils. The aim of the project is recognizing a less known animal – a carausius morosus and its life habitat, and therefore developing a positive relation to the animal. The pupils reveal and recognize the characteristics of live creatures and their life habitats by direct sistematic watching of and care for them. The author states that the pupils have recognized basic life needs of the carausius morosus, have softened fear of the unknown, have used their ante-knowledge and experiences, have developed their communicative abilities, healthy personal releationships and positive self-image spontaneously.

Keywords: *empirical learning, live creatures, carausius morosus, individual experience, science.*

UVOD

Otrok je po naravi vedoželjno bitje. Ko spozna okolico, se usmeri k tistemu, kar je zanj neznano. Naloga učitelja je, da učenca vodi in usmerja k pridobivanju novih neposrednih izkušenj ter ga spodbuja k raziskovanju novega. Z uporabo elementov konstruktivističnega pristopa pri učenju in poučevanju začetnega naravoslovja, torej z aktivnim vključevanjem učencev v različne konkretne naravoslovne dejavnosti, učitelj vodi učence do boljše naravoslovne pismenosti.

Z učenci drugega razreda sem izvedla dejavnosti na temo Spoznajmo paličnjaka. Dejavnosti so potekale dva tedna. Cilji, ki sem jih želela uresničiti so bili, da učenci: spoznavajo paličnjaka in njegovo življenjsko okolje; oblikujejo pozitiven odnos do živih bitij in narave; spoznavajo in začutijo, da obstaja komunikacija med človekom in živaljo, premagajo strah pred paličnjakom; razvijajo sposobnosti za lastno raziskovalno delo in usvajanje postopkov: opazovanje, razvrščanje, merjenje, eksperimentiranje, raziskovanje, sporočanje; razvijajo zdrave medosebne odnose in pozitivno samopodobo.

Razmišljanja, kako realizirati zastavljene cilje, so me pripeljala do sklepa, da moram učencem omogočiti neposredno izkušnjo, stik z živim bitjem - paličnjakom, ki bi ga učenci lahko spoznali in začutili z vsemi svojimi čutili.

METODA

Razmišljanja, kako naj učenci spoznajo paličnjaka, so me pripeljala do odločitve, da bi, paličnjaka opazovali v naši učilnici. Zato sem v učilnico prinesla kozarec, v katerem sta bila poleg zelenih listov robide tudi dva paličnjaka. Zavedala sem se, da so učenci še neizkušeni in neiznajdljivi, zato je še toliko bolj pomembno, kako jih bom vodila skozi dejavnosti. Za začetek sem pripravila nekaj vprašanj za učence (Kaj opazite v kozarcu? Se kaj premika? Opazite kaj nenavadnega? Katero žival opazite v kozarcu? Zakaj se tako imenuje? Zakaj je nismo takoj opazili? Bi jo želeli spoznati? Jo želi kdo prijeti?...).

V knjižnici smo poiskali ustrezno literaturo, ki pa je je bilo zelo malo. Po navodilih smo v stekleni posodi pripravili gojilnico. Učenci so paličnjaka poimenovali, opazovali vsak dan in vodili dnevnik opazovanja, v katerega so sproti beležili opažanja. Vsak dan so najprej opazovali paličnjaka v gojilnici, nato so ju postavili na klop in jima dovolili, da sta se premikala po njihovih rokah. Nihče ni nikogar silil, naj prime paličnjaka. Vsak je prvi korak napravil takrat, ko je sam čutil, da je na to pripravljen, da to zmore in si želi. Ostali so bili veseli vsakogar, ki se jim je pridružil. Mislim, da je deklica (drugače zelo zadržana), ki je zadnja prijela paličnjaka, premagala samo sebe in bila tudi zaradi tega zelo zadovoljna. Učenci so hranili, opazovali in primerjali obliko, barvo, velikost, gibanje, značilnosti ter posebnosti paličnjaka. Ob vsakodnevnem opazovanju sem učencem zastavljala akcijska (produktivna) vprašanja (Kaj? Iz česa je? Kako? Koliko? Kaj je skupnega? V čem se razlikujeta? Kaj se zgodi, če…? Kaj misliš, zakaj…?... s katerimi sem želela spodbuditi dejavnosti in razmišljanje učencev.

V tem času so učenci izvedli še nekatere dejavnosti drugih predmetnih področij, s čimer so, tako dejavnosti kot zastavljene cilje, medpredmetno povezovali. Že prvi dan so učenci odgovarjali na vprašanja o paličnjaku. S tem sem želela ugotoviti, kaj učenci znajo o tej živali. Paličnjaka so tudi risali. S ključem za določanje živali so ugotovili, da je to žuželka, kar so morali utemeljiti. Navedli so tri razloge, zaradi katerih so ga uvrstili v razred žuželk. Učenci so dobili nalogo: V času, ko smo spoznavali paličnjake, je tvoj sošolec manjkal pri pouku. Napiši, kaj si se o paličnjaku naučil, da se bo iz tega kaj naučil tudi on. V gibalni igri so posnemali paličnjaka v različnih razmerah (hodi, se prikrije, raziskuje,..). Pri likovni vzgoji so paličnjake naslikali. Nastali so zelo zanimivi izdelki. Nekateri učenci so na plakat narisali paličnjaka ter vpisali njegove dele telesa. Druga skupina je oblikovala miselni vzorec o paličnjaku. V zaključku so učenci ponovno odgovarjali na ista vprašanja kot v uvodnem delu. Odgovori so bili bistveno boljši.

Paličnjaka smo v učilnici obdržali še kar nekaj časa. V tem času sta znesla jajčeca iz katerih so se izlegli mladi paličnjaki. Tisti učenci, ki so želeli so paličnjake odnesli domov, kjer so zanje skrbeli in nam poročali o spremembah, ki so jih opazili pri svojih paličnjakih.

REZULTATI

Zastavljeni cilji so bili realizirani. Spoznavanje paličnjaka je bilo za otroke prav posebna in zelo zanimiva pozitivna izkušnja. Tudi sama sem z zanimanjem opazovala učence, s kako veliko vnemo so se lotili danih nalog in vztrajali do konca. Samo dva učenca sta paličnjaka videla že prej. Ker je bilo literature na to temo zelo malo, so bili prisiljeni se učiti z zelo natančnim in sistematičnim opazovanjem. Preko konkretnih aktivnosti so spoznali telesno zgradbo žuželke in funkcije njenih delov telesa, nekatere posebnosti paličnjaka, kot so: pojav prikrivanja - z obliko, barvo in vedenjem posnema rastline; ob nevarnosti zloži vse okončine tesno ob telo in negibno obleži, tudi več ur – katalepsija; paličnjak je običajno nočna žival; se levi; razmnožuje se z neoplojenimi jajčeci - partenogenetsko; ima zelo krhke noge, ki se hitro zlomijo, a kmalu zrastejo na istem mestu nove.

Učenci so odpravili, ali vsaj omilili, strah pred paličnjakom in nekaterimi drugimi nenevarnimi malimi živalmi. Začutili so, da obstaja pozitivna in negativna komunikacija s paličnjakom, če z njim lepo ravnamo, nam to tudi vrača. Spoznali so, da ima paličnjak svoje življenjske potrebe, da vsa živa bitja umrejo in se po smrti razgradijo. Spremenili so odnos do živali v naravi in spoznali, da ima vsako živo bitje svojo pomembno vlogo pri ohranjanju ravnovesja v naravi. Usvojili so novo izrazoslovje in z vsem tem prispevali k boljši naravoslovni pismenosti.

ZAKLJUČEK

Spremljanje praktičnega dela in analiza izdelkov učencev, ki so nastali med samimi dejavnostmi in ob preverjanju zastavljenih ciljev sta pokazala, da so učenci prišli do pomembnih spoznanj o paličnjaku. Z novimi izkušnjami so dopolnili in obogatili mnoge nejasne predstave o majhnih živalih, dopolnili svoje predznanje ter določena dejstva posplošili na vsa živa bitja Zelo pomembno je tudi, da so nekateri učenci premagali strah, ki so ga čutili do nekaterih malih živali in pridobili pozitiven odnos do le teh.

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EFFECT OF COOPERATIVE LEARNING IN BIOLOGY CLASS
/
UČINEK SODELOVALNEGA UČENJA PRI POUKU BIOLOGIJE

Lucija Lah

OŠ Šenčur

lucija.lah@guest.arnes.si

ABSTRACT

In our study we have checked the following hypotheses: cooperative learning is comparable to traditional learning, the knowledge acquired by cooperative learning lasts longer and the relations among pupils are improved. We performed a research which included 145 7-grade pupils, subject »natural science«. We chose three content-similar ecological themes (Forest, Ground and Continental Waters) which were treated by cooperative (the jigsaw method) and traditional learning. The statistical analysis of the results shows that knowledge acquired by cooperative learning is comparable to the knowledge acquired by traditional learning (also in terms of its durability) and that relations among pupils are improved.

Keywords: *cooperative learning/tradicional learning/biology/ecology/jigsaw*

UVOD

Ljudje smo socialna bitja, življenje v skupnosti in intenzivna interakcija z drugimi ljudmi je pogoj za naš razvoj in udejanjanje naših potencialov. Odnosi z drugimi so pomembni v vseh življenjskih obdobjih od najzgodnejšega obdobja v družini, kasneje v vrtcu, v šoli, skupinah vrstnikov, v partnerskih odnosih in na delovnem mestu. Kvaliteto teh odnosov in s tem uspešnost v življenju pa v veliki meri določa naše sodelovanje z ljudmi, ki nas obkrožajo.

Sama sem učiteljica biologije, naravoslovja in gospodinjstva v osnovni šoli. Pri učencih sem opazila, da imajo težave s sporazumevanjem med seboj in tudi z mano. Veliko se prepirajo, nekateri pa so popolnoma izolirani od drugih učencev. Pri ustem preverjanju in ocenjevanju znanja opažam, da nekateri učenci snov sicer razumejo, vendar imajo probleme pri izražanju. Rezultati nas ne bi smeli presenetiti, saj imajo učenci le malo možnosti za pogovor. S starši se pogovarjajo le malo, saj so le-ti dolgo časa v službah, med poukom učenci ne smejo klepetati, ko pridejo domov se usedejo pred računalnik ali pa pred televizijo.

»Sodelovalno učenje je učenje v majhnih skupinah, ki je strukturirano tako, da med člani skupine obstaja pozitivna soodvisnost, ko skušajo s pomočjo neposredne interakcije v procesu učenja doseči skupen cilj, pri tem pa se ohrani tudi odgovornost vsakega posameznega člana skupine« (Peklaj, 2001, str. 9).

METODA

Prvo hipotezo bomo potrdili oziroma ovrgli s preverjanjem znanja pri pouku naravoslovja v sedmem razredu devetletke, kjer so blok ure in je to še bolj ugodno za tak način dela.

Poučujem tri razrede s skupaj 80 učencev. Trikrat bomo ponovili poizkus tako, da bomo obravnavali novo snov s sodelovalnim učenjem v dveh razredih, tretji razred, pa bo kontrolna skupina in bo snov predelal s tradicionalnim učenjem. Kontrolna skupina bo vedno drug razred.

Ves postopek bomo ponovili še v naslednjem šolskem letu z naslednjo generacijo učencev, da bo število učencev večje in tako rezultati bolj realni. Skupno število vseh učencev, ki bodo sodelovali v raziskavi, bo tako 145.

Hipotezo, da je znanje pridobljeno s sodelovalnim učenjem trajnejše, kot znanje pridobljeno s tradicionalnim učenjem, bomo preverili s ponovnim preverjanjem znanja čez daljši čas (po šestih mesecih).

Hipotezo, da se odnosi med učenci v skupini z metodo sodelovalnega učenja izboljšajo, da se jim poveča želja po sodelovanju s sošolci in tudi priljubljenost učencev v razredu, bomo preverili z vprašalnikom, kjer bodo učenci izrazili svoje mnenje o sodelovalnem učenju in o vplivu takega načina dela na njihovo medsebojno razumevanje ter s socimetrično preizkušnjo pred in po delu z metodo sodelovalnega učenja.

Poskus smo izvajali pri skupno 42 šolskih urah, pregledali pa smo okoli 700 preizkusov znanja, 80 anket in 150 sociometričnih preizkusov. Prosojnice in primere organizmov smo pokazali vsem, tako pri tradicionalnem, kot pri sodelovalnem učenju.

REZULTATI

Postavili smo hipotezo, da med učenci, ki se učijo z različnima metodama učenja ne obstajajo razlike v rezultatih na preizkusih znanja. Na podlagi rezultata potrdimo hipotezo.

Testirali smo hipotezo, da je znanje sodelovalnega učenja pri populaciji trajnejše od tradicionalnega. V ta namen smo rezultate pri posameznih temah prve generacije, ki so preverjali znanje dvakrat med seboj odšteli, da bi ugotovili, kakšna je absolutna razlika med prvim in drugim preverjanjem. Populacijo smo nato razdelili samo glede na učenje (tradicionalno ali sodelovalno). Na podlagi rezultata hipotezo ovržemo.

Pokazati smo želeli, da so se odnosi v skupini z metodo sodelovalnega učenja izboljšali. To smo izmerili tako, da smo med seboj primerjali rezultate pred in po izvajanju sodelovalnega učenja, seveda posebej za prejete in oddane glasove. Ker smo pričakovali, da so se odnosi izboljšali, samo od prejetih (oddanih) glasov po izvajanju sodelovalnega učenja odšteli prejete (oddane) glasove pred izvajanjem sodelovalnega učenja. Če sodelovalno učenje ne bi imelo nikakršnega vpliva na rezultate, potem bi bila razlika enaka nič. V primeru, da so se rezultati izboljšali (naša hipoteza), pa je razlika pozitivna.

ZAKLJUČEK

Pozitivne socialne posledice sodelovalnega učenja so pomembne predvsem, ko je eden od ciljev izobraževanja tudi vključitev otrok, ki so pripadniki drugih ras, nacionalnosti ali pa otrok s posebnimi potrebami.

Nesprejemanje kakorkoli drugačnih otrok v šoli je sedaj še posebej pereč in aktualen problem. Zato predlagam, da večkrat uporabimo tudi sodelovalno učenje, saj smo dokazali primerljive rezultate s tradicionalnim načinom učenja v preizkusih znanja in v trajnosti znanja, pomembno pa so se izboljšali odnosi med učenci. Naredili bi lahko še prej omenjene izboljšave in proučili še učinek le-teh. Seveda bi bili rezultati še bolj zanesljivi, če bi bilo število učencev večje. Zanimivo bi bilo narediti raziskavo tudi pri predšolskih otrocih, na srednjih šolah, pa tudi na fakulteti med študenti.

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A SYSTEMATIC APPROACH TOCLASS BIOLOGY TEACHERS TO COPE WITH STRESS AT SCHOOL / SISTEMATIČNI PRISTOP UČITELJA K POUKU BIOLOGIJE ZA LAŽJE OBVLADOVANJE STRESA V ŠOLI

Sabina Lepen Narić

Gimnazija Jožeta Plečnika Ljubljana

inaprofbio@gmail.com

ABSTRACT

In his contribution to the case showed how a teacher of biology, despite the teeming masses of information, the expected goals, daily appointments and obligations, systematic approaches to teaching and its regularized, with as little stress contributes to systematic knowledge acquisition in general high school biology.

Contribution offers teachers of biology, which for various reasons, can not find the time, formal, mandatory lesson preparation. Teachers provide an overview of the learning objectives of individual lessons and gradual ownership of new concepts. It also proposed a form and method of work for each lesson. Further assistance has made teacher ppt presentations on specific topics and individually designed worksheets and tests for examinations.

Keywords: *educational preparation, virtual classroom, ppt presentations, control of stress in the learning process*

UVOD

V nastajajočem didaktičnem priročniku bodo učitelji našli učne priprave za vseh 70 ur biologije v vseh treh letnikih, kar znaša blizu 210 priprav. V tokratnem prispevku je predstavljena le ena od 210 priprav na učno ure biologije.

Izdelane učne priprave (Tabela 1) lahko učitelj poljubno spreminja, dograjuje oziroma jih sproti prilagaja in bogati. Lahko pa si na podlagi ideje izdela povsem nove priprave. Kljub temu ima možnost prihranka dragocenega časa in energije, saj mu ponujam okviren osnutek priprave. V veliko pomoč je lahko učiteljem začetnikom ali pa starejšim učiteljem, ki še niso tako vešči moderne informacijske tehnologije.

METODA

V učno pripravo (Tabela 1) lahko poljubno vnašajo razred, datum in leto poučevanja, izbirajo med metodami in oblikami dela, med učnimi pripomočki oz. sredstvi poučevanja. V posebno rubriko lahko vnesejo literaturo, ki jo uporabljajo pri pouku. V posamezno učno pripravo so že vneseni učni cilji iz posodobljenega učnega načrta ter novi pojmi, obravnavani pri posamezni uri. Učne cilje lahko po lastni presoji zamenjajo, premestijo ali pa enostavno izbrišejo. Za posamezno učno uro je že predlagana uvodna motivacija, glavni del ure in zaključek, skupaj z okvirno časovno razporeditvijo dela. V glavnem delu ure je zapisan vsebinski, teoretični del, ki učitelja spomni, kaj vse mora obdelati v tej uri. S ppt prezentacijo dijaku omogoči lažje razumevanje učne vsebine, saj elektronske prosojnice vsebujejo veliko slikovnega materiala. Biologija je predmet, ki ga je nujno potrebno razlagati ob slikovnem gradivu. Tudi ppt predstavitvijo lahko učitelj poljubno spreminja in prilagaja. V rubriki delo dijakov je navedeno, kakšne zadolžitve imajo dijaki tekom učne ure in domače delo. Zavedena so tudi mesta v obstoječi literaturi, kjer lahko dijaki usvojijo in utrdijo ter nadgradijo v uvodu navedene cilje. Učnim pripravam so dodani tudi delovni listi za utrjevanje učne snovi in testi za preverjanje znanja. Ker pa uporabljamo tudi spletno učilnico sem predstavila eno izmed možnih poti za ureditev izobraževanja posameznih skupin oz. razredov.

Dijaki si lahko preko spletne učilnice doma še enkrat ogledajo ppt prosojnice, saj med poukom nimajo časa prepisovati, slikovno gradivo pa je seveda potrebno večkrat pogledati in preučiti. Še posebno je v veliko pomoč spletna učilnica odsotnim dijakom, ki iz različnih vzrokov ne morejo biti pri pouku. Učitelj lahko objavi v spletni učilnici tudi priprave, tako so dijaki sproti seznanjeni s cilji in ostalimi komponentami učne ure.

REZULTATI

Tabela 1: Primer učne priprave

<table>
<tr><td>ŠOLSKO LETO:</td><td></td><td colspan="2" rowspan="4">PRIPRAVA
NA
VZGOJNO-IZOBRAŽEVALNO DELO</td><td></td><td></td></tr>
<tr><td>RAZRED:</td><td></td><td></td><td></td></tr>
<tr><td>ZAPOREDNA ŠT. URE:</td><td></td><td></td><td></td></tr>
<tr><td>DATUM REALIZACIJE:</td><td></td><td></td><td></td></tr>
<tr><td colspan="6">PREDMET: B I O L O G I J A- splošna gimnazija</td></tr>
<tr><td colspan="6">UČNA TEMA: OSNOVNE VRSTE DEDOVANJA</td></tr>
<tr><td colspan="6">UČNA ENOTA: Dedovanje – Dihibridno križanje</td></tr>
<tr><td colspan="6">VZGOJNO IZOBRAŽEVALNI CILJI:
Dijaki:
- razumejo osnovne vrste dedovanja (dihibridno dominantno-recesivno križanje, ter jih razložijo na primerih (pričakovani deleži genotipov in fenotipov potomcev) (D 3/1)
- na primerih iz genotipov organizmov predvidijo njihove fenotipe in obratno ter poznajo
možne vplive okolja na fenotip (D3/2)</td></tr>
<tr><td colspan="6">Novi pojmi: dihibridno križanje</td></tr>
<tr><td>Tip ure :</td><td>uvodna</td><td>nova snov</td><td>utrjevanje</td><td>preverjanje</td><td>ocenjevanje</td></tr>
<tr><td>Učne oblike :</td><td>frontalna</td><td>individualna</td><td>skupinska</td><td>dvojice</td><td>referat</td></tr>
<tr><td>Učne metode :</td><td>razlaga</td><td>razgovor</td><td>demonstracija</td><td>terensko delo</td><td>laboratorijsko delo</td></tr>
</table>

	grafični izdelki-plakat	**reševanje problemov**	**delo s tekstom**	video ali računalnik	igra vlog
Zaporednost etap :	uvajanje	**usvajanje**	**urjenje**	ponavljanje	preverjanje
Učila in učni pripomočki :	grafoskop **tabla**	televizija video	mikroskop merilni instrum.	kamera **računalnik**	teksti revije
	Drugi (material za vaje, učni listi,lab. material, teksti...), **delovni zvezek,** **ppt: Dihibridno križanje (*L.N. Sabina*)**				
Literatura :	Samo Kreft, Sonja Krapež, GENETIKA IN EVOLUCIJA, MODRIJAN 2006 Tracey Greenwood: BIOLOGIJA za gimnazije: delovni zvezek, Modrijan, 2008				

ETAPA IN ČAS:	**POTEK DELA NASLOV: Dedovanje – dihibridno križanje**	
	DELO UČITELJA:	**DELO DIJAKA:**
15 min 20 min 10 min	**Uvodno ponavljanje:** Pregled domače naloge DZ str. 62-64 - Monohibridno križanje - Dominanca alelov **Rzširitev:** **DIHIBRIDNO KRIŽANJE – 2. MENDLOV ZAKON:razlaga s pomočjo ppt prezentacije , objavljene v spletni učilnici ECHO*(www.egradiva.si)*** Opazujemo dedovanje dveh lastnosti oz. dveh genov. Če križamo med seboj homozigotne starše za obe lastnosti (P), nastane v F1 generacija samo ena vrsta potomcev (100% enaki heterozigoti). Če sta gena za obe lastnosti na različnih kromosomih in se med mejozo razporejata neodvisno drug od drugega, nastajajo štiri različne gamete. Pričakovano razmerje fenotipov in genotipov v F2 generaciji lahko prikažemo z Punnettovim kvadratom (rekombinacijski kvadrat).To razmerje je 9:3:3:1. **Zaključno ponavljanje:** DZ. Str. 65, 66 *Dihibridno križanje*	- Pokažejo naloge iz delovnega zvezka. -Sledijo razlagi na tabli in prepišejo diagram križanja. -Utrjujejo snov in zabeležijo navodila za domačo nalogo: DZ. Str. 65, 66 *Dihibridno križanje* Doma ponovijo in utrdijo znanje v spletni učilnici kjer rešijo test.

ZAKLJUČEK:

V razširjenem povzetku je predstavljena ena izmed mnogih učnih priprav pouka biologije na gimnaziji. Učitelj lahko s sistematično izdelanimi in urejenimi pripravami, vestno opravi svoje delo, načrtovano vodi dijake skozi izobraževalni proces, dijakom pa poleg dela v šoli, ponudi tudi možnost samostojnega domačega dela in preverjanja znanja v spletni učilnici. Tako ustvari manj stresno delovno okolje za samega dijaka in tudi za učitelja.

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EVALUATION OF THE INFLUENCE OF VARIOUS METHODS OF EXPERIMENTAL WORK ON QUALITY AND DURABILITY OF CHEMISTRY KNOWLEDGE
/
VREDNOTENJE VPLIVA OBLIKE EKSPERIMENTALNEGA DELA NA KAKOVOST IN TRAJNOST ZNANJA KEMIJE

Ana Logar

OŠ Metlika

ana.logar@gmail.com

Vesna Ferk Savec

Univerza v Ljubljani,
Naravoslovnotehniška fakulteta

vesna.ferk@ntf.uni-lj.si

ABSTRACT

The presented research aimed to provide information about the most appropriate method for experimental work (teachers` demonstration experiment or students` experimental work in couples) in primary school chromatography topics from quality and durability of knowledge points of view. The results were collected with a pre- and two post- knowledge tests, working sheets accompanying experimental work and structured interviews with students, and processed both with qualitative and quantitative methods of data analysis. The results indicate, that students gain better and longer lasting knowledge by demonstration experiments, however they prefer conducting experiments by them-selves.

Keywords: *experiment, demonstration experiment, experimental work in couples, chemistry*

UVOD

V predstavljeni raziskavi smo preučevali, katera izmed izbranih oblik eksperimentalnega dela (demonstracijski eksperiment ali eksperimentalno delo učencev v paru) je v osnovni šoli bolj primerna za poučevanje in učenje izbrane učne vsebine iz vidikov: (1) učenčeve uspešnosti pri spremljanju poteka eksperimenta, (2) usvajanja novega znanja in (3) trajnosti usvojenega znanja. V raziskavi smo želeli izvedeti tudi, kakšne so prednosti in slabosti posameznih oblik eksperimentalnega dela skozi oči učencev.
Raziskave smo se lotili na podlagi pregleda pomena eksperimentalnega dela številnih raziskovalcev, ki preučujejo vlogo eksperimentiranja in izkustvenega pouka v okviru naravoslovja. Z vključevanjem te oblike dela naj bi tako: spodbujali radovednost in motivirali učence za naravoslovje, teoretično znanje preverili z ustreznimi eksperimenti, navajali na opazovanje, obdelavo, vrednotenje in prikaz rezultatov, olajšali razumevanje in učenje kemije, približati pojme in jih usvojili preko izkušnje, razvijali laboratorijske spretnosti, usvajanje eksperimentalnih tehnik in metod, pravilna uporaba šolske opreme, navajanje na upoštevanje navodil in varnostnih ukrepov, popestrili pouk (Johnstone in Al-Shuaili, 2001).

Nekateri avtorji opozarjajo, da velikokrat precenjujemo pomen eksperimentalnega dela in navajajo številne slabosti eksperimentalnega dela: učenci pri delu sledijo navodilom, ne da bi pri tem razmišljali o namenu eksperimenta, učenci ne iščejo povezav med eksperimentom in pojmi, ki so jih že usvojili pri pouku, zaradi nezadostnega predznanja učenci ne vedo, na kaj morajo biti pozorni pri eksperimentu in ne znajo razložiti opažanj, učenci ne vidijo zveze med načrtovanjem eksperimentalnega postopka in namenom raziskave, nekaterim učencem eksperimentalno delo predstavlja le odmor med običajnim, teoretično naravnanim poukom in ne kot intelektualni izziv za večino učencev so laboratorijske aktivnosti prezahtevne (Hodson, 1996).

V splošnem lahko povzamemo, da naj glede na učni cilj, ki ga želimo doseči, učitelji izbirajmo ustrezno obliko aktivnosti, ki je v danih okoliščinah najprimernejša.

METODA

Za namen raziskovalnega dela je bila razvita učna enota za vsebino kromatografije, za spremljanje napredka v znanju učencev predtest, potest in delovni list ter strukturirani intervju za poglobljeno preučevanje dojemanja eksperimentalnega dela skozi oči učencev (Logar, 2008). Zbrani rezultati so bili obdelani ob uporabi uveljavljenih kvantitativnih in kvalitativnih metod analize podatkov.

V raziskavi je sodelovalo 107 devetošolcev, ki smo jih glede na rezultate predtesta razdelili v dve enakovredni skupini, kontrolno in eksperimentalno skupino. Z eksperimentalno skupino smo izvedli učno uro z izvedbo eksperimentalnega dela v obliki učiteljeve demonstracije, s kontrolno skupino pa podobno učno uro z izvedbo eksperimentalnega dela v obliki eksperimentiranja učencev v parih.

REZULTATI

Uspešnost učencev smo preverjali s potestom (potest 1) takoj po učnem procesu in nato čez štirinajst dni ponovno z istim potestom (potest 2). Ugotovili smo, da so bili na *potestu 1* učenci eksperimentalne skupini uspešnejši od učencev kontrolne skupine ($t = 2{,}6$; $p<0{,}05$); najbrž zato, ker so bili skozi uro eksperimentiranja vodeni s strani učitelja demonstratorja, ki je usmerjal učence k opazovanju ključnih eksperimentalnih rezultatov in poudaril bistvene ugotovitve. Na *potestu 2* - pa je razlika med eksperimentalno skupino in učenci kontrolne skupine statistično nepomembna, ($t = 0{,}97$; $p>0{,}05$), torej sta obe skupini v trajno pridobljenem znanju izenačeni. Iz rezultatov sklepamo, da če učenci sami eksperimentirajo, znanje, ki ga osvojijo tisto uro ostane daljši čas na približno enakem nivoju, medtem ko učenci, ki spremljajo učiteljevo demonstracijsko izvedbo eksperimenta trenutno veliko znajo, vendar brez utrjevanja znanja del pridobljenega znanja hitro pozabijo.

Zanimala nas je tudi uspešnosti učencev pri sledenju izvedbe eksperimenta, kadar je le-ta izveden z eno izmed izbranih oblik eksperimentalnega dela. Analiza izpolnjenih delovnih listov učencev je pokazala, da je razlika v uspešnosti med skupinama statistično nepomembna ($t = 0{,}34$; $p>0{,}05$), torej sta bili obe skupini učencev enako uspešni.

V raziskavi smo s strukturiranim intervjujem skušali ugotoviti prednosti in slabosti preučevanih oblik eksperimentalnega dela skozi oči učencev. Ugotovili smo, da učenci raje delajo v parih, navajajo, da tako lažje razumejo snov, učijo se praktičnih veščin, bolje vidijo eksperiment, sodelujejo med seboj, delo si porazdelijo, so aktivni pri pouku in se ne dolgočasijo, kar se sklada z navedbami drugih raziskav.

ZAKLJUČEK

Povzamemo lahko, da vodi izvedba demonstracijskega eksperimenta (kratkoročno) do bolj kvalitetnega znanja, učenci pa raje eksperimentirajo sami, zato je v pouk smiselno vključevat oboje. Za ugotovitev ali je katera izmed primerjanih oblik dela primernejša za pridobivanje trajnega znanja pa bi bilo potrebno spremljati znanje učencev skozi daljše časovno obdobje v nadaljnjih raziskavah.

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INNOVATION IN TEACHING TECHNIC AND TECHNOLOGIES
/
INOVATIVNOST PRI POUKU TEHNIKE IN TEHNOLOGIJE

Mojca Milone

OŠ Solkan

mojca.milone@guest.arnes.si

Barbara Vetrih Bolčina

OŠ Solkan

bvetrih@gmail.com

ABSTRACT

During our lessons we motivate students' project work through the problem-solving task so that they could develop their creativity through ideas and practical application. Through years of teaching we have observed that students are best involved if we give them a problem and stimulate them to search for solutions. The project is intertwined and overlapping with knowledge from different fields, usually already achieved from personal experiences of fourteen-year-old students. We guide them through all the steps of the development of their idea: from the sketching to critical evaluation and comparison of their final work with the others.

Keywords: *teaching techinc, differentation, problem aproach, improvement, creative thinking.*

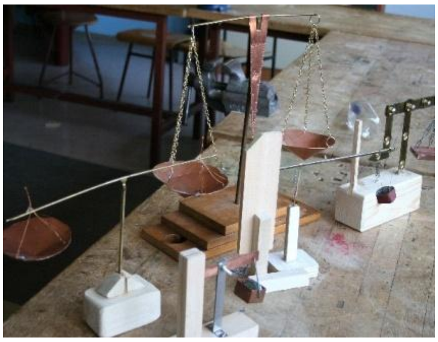
UVOD

Za uspešen razvoj sodobne družbe je potrebno že naše najmlajše navajati na iskanje novih, izvirnih idej, ki nas lahko v širokem, konkurenčnem okolju naredijo posebne in zanimive. Zato tudi pri šolskem delu spodbujava učence k inovativnosti. Na tak način pa razvijava občutek za prepoznavanje problemov družbe, ustvarjalnost in vizijo za izboljšave.

METODA

Pri načrtovanju daljšega projektnega dela je potrebno ugotoviti predznanje in izkušnje učencev osmih razredov ter upoštevati vse pogoje in časovne omejitve, ki jih določa učni načrt. Učence spodbudimo v iskanje čim bolj originale rešitve na zastavljen izziv: **Ali lahko star, zavržen dežnik postane uporabna tehtnica?**

V celotnem procesu učenci uporabljajo tudi znanja, ki so jih pridobili pri pouku fizike, matematike, naravoslovja. Pri tem izstopa transfer znanja, kot prenašanje učinka iz ene naučene dejavnosti na drugo. Pogosto se pri učencih izkaže želja po pridobivanju novega, uporabnega znanja v oblikah logičnega sklepanja, hipotetičnega razmišljanja, do pridobivanja ročnih spretnosti ob pravilni in varni uporabi orodij in naprav. Učence usmerjamo tudi v razvijanje lastne čustvene inteligence kot preskoka v razmišljanju in iznajdljivosti, prilagajanju in opazovanju osebnega napredka. Skozi takšno projektno delo lahko učenci dosežejo veliko operativnih ciljev: od iskanja izvirne ideje, preko delovnih obdelovalnih postopkov do preizkusov delovanje svojega izdelka. Pri spodbujanju ustvarjalnosti med mladimi lahko uporabimo različne metode poučevanja, ki jih izbiramo tudi glede na individualne potrebe učencev: metode razgovora, opisovanja, risanje in branje skice-načrta (metoda grafičnih del), metodo demonstracija, praktično delo (ročni in strojni postopki), metode sodelovalnega učenja – izmenjave izkušenj.



Slika1: Izdelki učencev-prevesne in vzvodne tehtnice

REZULTATI

Učenci so bili skozi celoten projekt, ki je trajal osem šolskih ur, visoko motivirani in uspešni, kar se je izkazalo v skupnem zaključnem razgovoru. Rezultati dela se kažejo izboljšanju medsebojnih odnosov med učenci - učiteljicami ter v inovativnih, končnih izdelkih, ki so se med seboj razlikovali v principu delovanja in izvedbah. Pri oblikovanju posodic za tehtnico so si učenci predhodno načrtovali in izdelali mrežo telesa. Pri proučevanju možnosti pritrjevanja posodic so samostojno preučevali najboljše pogoje za ravnovesje. Svoje ugotovitve so sproti beležili, pri tem pa iskali izvirne rešitve za izdelavo čimbolj unikatnega izdelka.

Ko so preverili delovanje naprave, so iskali možnosti izboljšav za doseganje še večje točnosti tehtnice. Učence sva sproti in pogosto opozarjali tudi na varno izvedbo vseh praktičnih postopkov in na uporabo zaščitnih sredstev. Učenci so tudi določili ceno izdelka in sodelovali pri določanju kriterijev vrednotenja izdelkov. Skozi celoten projekt je bilo čutiti pretok izmenjave izkušenj med vrstniki, prav tako pa so se učenci pogosto posvetovali tudi za nama. Nekateri končni izdelki so bili zelo inovativni in uporabni, tako da so učenci presegli naša pričakovanja.

ZAKLJUČEK

Ugotovili sva, da preučevanje zavrženih naprav in predmetov v mladih vzbuja razmišljanje o spremembi uporabe nekaterih delov, s tem pa razvijamo tudi čut za opazovanje in recikliranje. Poseben izziv vidiva tudi v tem, da se tudi medsebojno dopolnjujeva in prilagajava različnim potrebam učencev, tako da vsi dosežejo zastavljen cilj. Tako vodiva k inovativnosti učence, ki so bolj nadarjeni na tehniško ustvarjalnem področju in tudi ostale, ki pri iskanju rešitev potrebujejo pomoč.

Predstavljeni projekt je že preverjeni primer dobre prakse, kako lahko učencem s prepletanjem učnih vsebin dokažemo uporabnosti matematično naravoslovnih predmetov za iskanje praktičnih rešitev. Najini predlogi za učence prihodnjih generacij nakazujejo na drugačne izdelke insicer take, ki lahko nastanejo iz uničenega geometrijskega orodja, porabljenega kemičnega svinčnika, zavržene embalaže, elektromotorjev iz neuporabnih igrač, električnih zobnih ščetk,…ipd.

Takšen način šolskega dela, ki temelji na problemskem pristopu, pa mora biti s strani učitelja dobro planiran načrtovan in organiziran, tako da bo pouk za učence prijazen, zanimiv in primerno zahteven, predvsem pa varen in učinkovit, saj v njem vidiva priložnost za celostni razvoj otroka.

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Fotografija: Mojca Milone

TEACHING TECHNICAL SUBJECTS WITH THE SUPPORT OF VIRTUAL CLASSROOMS
/
SPLETNE UČILNICE KOT DOPOLNILO PRI UČENJU STROKOVNIH PREDMETOV

Igor Petrovčič

Elektrotehniško-računalniška strokovna
šola in gimnazija Ljubljana

igor.petrovcic@gmail.com

ABSTRACT

This paper presents the usage of virtual classrooms as the effective support to the classical face-to-face teaching methods, with the focus on the technical subjects in the field of electrotechnics. Moodle enables e-materials to be used in the optimal way, provided that the teacher constantly keeps supervising the activities of his/her students. Additionally, due to the function of generating random data values, students always get individual assignments, which require and encourage individual work.

Keywords: *electrotechnics, e-materials, e-learning, Moodle*

UVOD

V času vse težje gospodarske situacije postaja znanje toliko bolj pomembno, zato je eden od osnovnih ciljev šole dijake čim bolje pripraviti za delo oziroma nadaljnji študij. Področje tehnike in naravoslovja zahteva *razumevanje* snovi, ne le učenje na pamet, kar pomeni kompleksnejši učni proces kot le učenje iz knjig. Dejstvo je, da se dijaki brez učiteljeve razlage, laboratorijskih vaj in obilo lastnega dela stroke ne morejo naučiti. Obenem je za precej dijakov značilno, da k učenju pristopajo kampanjsko in po najmanjši liniji odpora.

NEIZKORIŠČENI POTENCIAL E-GRADIV

Razvoj interaktivnih gradiv je vsekakor pripomogel k večji razgibanosti pouka, vendar to še ni dovolj za boljše znanje dijakov. V praksi se je namreč izkazalo, da so dijaki sicer navdušeni nad številnimi e-gradivi, s katerimi so se seznanili med urami strokovnih predmetov, vendar tovrstni materiali zahtevajo določeno mero samodiscipline. Brez mehanizma, ki tudi spremlja dejavnosti dijakov, še tako dobra e-gradiva ne morejo biti optimalno izkoriščena.

Poskus rešitve tega problema je uvedba spletnih učilnic, ki bi služile kot dopolnilo pri poučevanju strokovnih predmetov na Elektrotehniško-računalniški strokovni šoli in gimnaziji Ljubljana. Dijaki naše šole so imeli že vrsto let pred tem na razpolago e-gradiva, ki sem jih pripenjal na šolsko internetno stran, da bi jim olajšal učenje, vendar nisem imel vpogleda, v kolikšni meri se jih dijaki res poslužujejo.

METODA

Da bi ugotovil, ali je mogoče učni uspeh s kontrolirano rabo interaktivnih gradiv izboljšati, sem uporabil komparativno metodo. Na začetku šolskega leta sem pouk strokovnih predmetov izvajal le na klasični način, v učilnici, pri čemer sem dijakom predstavil tudi obstoječa e-gradiva, jih spodbujal, naj snov predelajo, jih večkrat napotil na uporabo e-gradiv in »zaupal« njihovi besedi, da so vaje resnično opravili. Po predelanem tematskem sklopu je sledilo preverjanje znanja. Zatem sem e-gradiva preselil v spletne učilnice, pri čemer sem dijake seznanil s tem, da imam vpogled v njihove dejavnosti.

Vaje so bile istega tipa kot pri klasičnem pouku, razlika je bila le v eni pomembni podrobnosti. Pri vsakem reševanju naloge so se podatki naključno spreminjali, tako da dijaki nalog niso mogli enostavno prepisati od sošolcev. Vaje smo sprva skupaj reševali pri urah, da so se dijaki spoznali z novostjo, potem pa so jih reševali samostojno za domače naloge. Po predelanem tematskem sklopu je sledilo ponovno preverjanje znanja. Rezultati testov bodo prikazani v nadaljevanju, v tabeli 1.

SPLETNE UČILNICE V MOODLU

Iz zgoraj omenjenih vzrokov, kot tudi iz potrebe po boljšem pregledu osvojene snovi in težav, ki se pri učenju pojavljajo, sem začel uporabljati spletne učilnice v okolju Moodle. To okolje je idealna rešitev za dosego zadanih ciljev, saj poleg številnih možnosti omogoča tudi sledenje dejavnosti.

Dejavnosti v okviru Moodla so izjemno uporabne pri laboratorijskih vajah, saj omogočajo, da dijaki isto vajo rešujejo timsko, a obenem povsem individualno, kar bo prikazano tudi na primeru ene od letošnjih spletnih učilnic. Naloge so namreč izdelane tako, da dosežemo naključno spreminjanje vrednosti podatkov. Individualno delo je zagotovljeno tudi za domače naloge, saj jih dijaki ne morejo prepisovati, hkrati pa odpade »pregledovanje zvezkov« med urami, kar sicer vzame precej časa, ki ga lahko bolje izkoristimo za obdelavo snovi.

REZULTATI

Z uvedbo spletnih učilnic in stalnega nadzora nad dejavnostmi posameznikov se je znatno izboljšal tudi učni uspeh pri strokovnih predmetih. Tabela 1 prikazuje skupne rezultate treh razredov drugega letnika

Tabela 1: Učni uspeh pri nekontrolirani in kontrolirani rabi e-gradiv

doseženi rezultati (NMS-5)	ocene testa pred uvedbo spletne učilnice (vzorec: 80 dijakov)	ocene testa po uvedbi spletne učilnice (vzorec: 83 dijakov)
odlično (5)	6	19
prav dobro (4)	4	10
dobro (3)	6	14

zadostno (2)	14	12
NMS	50	28
povprečna ocena	1,775	2,759

ZAKLJUČEK

Moodle se je izkazal kot dobra motivacija za dijake, saj udeleženci vedo, da je učitelj seznanjen z njihovim delom. Po drugi strani so dobljeni podatki izredno koristni tudi za učitelje, saj predstavljajo zanesljive povratne informacije o težavnejših mestih pri razumevanju stroke.

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TEHNICAL CREATIVITY IN THE FORM OF PROJECT WORK WITHIN THE CURRICULUM OF THE TECHNICAL DAY FROM 1 st TO 9 th GRADE
/
TEHNIČNA USTVARJALNOST V OBLIK PROJEKTNEGA UČNEGA DELA V OKVIRU TEHNIŠKEGA DNE OD 1. DO 9. RAZREDA

Ivan Pišek

OŠ Griže

Ivan.Pisek@guest.arnes.si

ABSTRACT

Technical days often take the form of a learning project work. This way of learning is one of those forms which are based on experiential learning and which encourage students to funcition actively in all stages of work (planning tasks, collecting data, designing statements, presentations). Technical days enable to develop team cooperation within the school expert working groups.

The ultimate goal of technical day which is described in the contribution was to make an useful product

on the christmas holidays theme in all classes. Class teachers and students made an agreement about the basic material for the work. Students prepared an exhibition of finished products with the help of the class teachers. Parents were also able to see them at the parental meeting.

Keywords: *educational project work, team cooperation, technical days, tehnical creativity*

UVOD

Dnevi dejavnosti so tisti del obveznega programa osnovne šole, ki medpredmetno povezujejo discipline in predmetna področja, vključena v predmetnik osnovne šole. Cilji dni dejavnosti so omogočiti učenkam in učencem utrjevanje in povezovanje znanj, pridobljenih pri posameznih predmetih in predmetnih področjih, uporabljanje teh znanj in njihovo nadgrajevanje s praktičnim učenjem v kontekstu medsebojnega sodelovanja in odzivanja na aktualne dogodke v ožjem in širšem družbenem okolju. Tehniški dnevi se povezujejo s cilji tehnike in tehnologije ter gospodinjstva. V tem šolskem letu smo se prvič lotili izvedbe tehniškega dne od 1. do 9. razreda. Vidno je bilo veliko sodelovanja tako med učitelji kot učenci.

METODA

Težišče načrtovanja je bilo izvedeno v okviru strokovnih aktivov in se je izvajalo kot timsko delo vseh učiteljev na šoli. Temeljni cilj tehniškega dne je bil izdelati uporaben izdelek na temo božično-novoletnih praznikov, ki ga lahko otroci nesejo domov. Učitelji razredniki so dogovorili skupaj z učenci uporabo osnovnega materiala za delo. Učenci so tako ta dan ustvarjali iz papirja, gline, moosgumija, stekla, tekstila. Vsem tem materialom pa so dodali še mnoga druga (tudi naravni material, ki so ga uporabili učenci 9. razreda, da so izdelali namizno dekoracijo). Dogovorjeni cilji, ki smo jim v teh dneh sledili, so bili:

- spoznati decembrske praznike,

- predstaviti običaje ob praznikih v mesecu decembru,

- raziskati zgodovino posameznih praznikov,

- izdelati voščilnice iz različnih materialov v različnih tehnikah,

- izdelati okraske iz različnih materialov za okrasitev doma in šole,

- dokumentirati dogajanje,

- ovrednotiti opravljeno delo in pripraviti razstavo.

Najprej so učenci dobili osnovna navodila za delo, uporabo materialov in pripomočkov. Prevladovale so medote demonstracije, razlage, praktičnega dela. Učitelji razredniki in nerazredniki smo učencem utemeljili pomen natančnosti izdelave in estetskega izgleda izdelka. Posebno pozornost smo učitelji izvajalci namenili skrbi za varnost (pravilni uporabi orodij: škarij, klešč … in pravilni uporabi naprav na električni tok: pečica, lepilna pištola …).

REZULTATI

V prvem razredu so učenci uporabili pri izdelovanju izdelkov stiropor, krep papir, dass maso in dekorativni material. Izdelali so venčke, voščilnice in figurice za novoletno jelko. Učenci drugega razreda so uporabili glino. Izdelali so svečnike in prašičke za srečo. V tretjem razredu so se odločili izdelati uporaben izdelek iz moosgumija (tablo za urnik in pomembne datume), da bodo odslej redno v šolo nosili vse potrebno. Četrti razred je iz gline izdeloval posode in ptičke. Učenci obeh petih razredov so pri delu uporabili papir. Izdelali so zvezde, voščilnice in svečnike. V šestem razredu so oblikovali papir v voščilnice. Iz dass mase so naredili posode za bonbone. Nekateri pa so naredili sliko s pomočjo sukanca. Za učence sedmih razredov je bil tehniški dan organiziran zunaj šole (v steklarski delavnici). Naučili so se poslikave na steklo z barvami. Izdelali so okvirje za slike in hišne številke s postopkom fuzije. Izdelali so tudi ogledala s pomočjo peskanja. V osmem razredu so dali poudarek izdelovanju iz tekstila. Vsak učenec je izdelal božično nogavico in snežaka, ki je imel osnovo iz stiropornih kroglic. Deveti razred je s pomočjo naravnega in dekorativnega materiala izdeloval adventne venčke. Ustvarjali so ob pomoči učiteljice in učenk iz srednje vrtnarske šole Celje.

Spodnje slike prikazujejo izdelke, ki smo jih razstavili na skupnem roditeljskem sestanku 3.12. 2009, v telovadnici šole.

Slika 1: Izdelki 1. r

Slika 2: Izdelki 2. r

Slika 3: Izdelki 3. r

Slika 4: Izdelki 4. r

Slika 5: Izdelki 5.a

Slika 6: Izdelki 5. b

Slika 7: Izdelki 6.a

Slika 8: Izdelki 6. b

Slika 9: Izdelki 7. a in b

Slika 10: Izdelki 7.a in b

Slika 11: Izdelki 8. r

Slika 12: izdelki 9. a

Slika 13: Izdelki 9. b

Slika 14: Izdelki na razstavi

Slika 15: Izdelki na razstavi

Slika 16: Učenci pri delu

ZAKLJUČEK

Učenci so pri delu pokazali izvirnost in ustvarjalnost. Ponosni smo bili, saj so izdelke dokončali vsi.

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Updating chemistry teaching in the academic track of secondary school
/
Posodabljanje pouka kemije v gimnazijskih programih

Anita Poberžnik
Zavod RS za šolstvo
anita.poberznik@zrss.si

Nadja Malovrh
Zavod RS za šolstvo
nadja.malovrh@zrss.si

ABSTRACT

With the updating of grammar-school programs and chemistry teaching we lay stress on competence oriented education. In this way we stimulate student activity and their participation in creation of chemistry lessons. The updated curriculum plans of chemistry teaching in grammar-school stimulate and make possible teacher's autonomy. Teachers can search and develop their own way of learning/teaching goals achievement (student's activities, arrangement of learning complex, content…).

School-subject development group for chemistry in grammar-school together with teachers – mentors develop professional groundwork tested in practice. The results are used within regular professional staff training – for chemistry teachers and their laboratory assistents in grammar-schools.

***Keywords**: chemistry, updating of grammar-school programs, curriculum plan, introduction, education*

UVOD

Živimo v skupnosti, kjer je edina stalnica dejstvo, da se vse spreminja. Spreminjajo se vzorci zaposlovanja, preživljanje prostega časa, vrednote, spreminjajo se temeljna znanja in veščine, potrebna za uspešno delo in življenje. Tem spremembam sledijo tudi koncepti in načini pridobivanja znanj in veščin, ki razvijajo inovativnost, ustvarjalnost in fleksibilnost pri povezovanju znanj različnih predmetnih področij. V ospredju so vrednote, ki razvijajo osebno odgovornost, veščine in strategije učenja (spoznavanje) ter prepoznavanje konceptov, ki so skupni različnim področjem dela. Vse to pa zahteva spremembe v vseh dokumentih, ki se navezujejo na izobraževanje, še posebej v učnih načrtih. Za kemijo kot splošno-izobraževalni predmet v gimnazijah, že dolgo ne velja več, da je obvladovanje temeljnih konceptov znanja in usvajanje osnovnih veščin laboratorijskega dela dovolj, da bi dijaki predmet lahko povezovali z drugimi predmetnimi področji oz. pridobljena znanja tudi funkcionalno uporabljali. Poučevanje in učenje kemije zato mora spreminjati iz vsebinskega in didaktičnega vidika. Znanje ni več opredeljeno le z rezultati (katere učne vsebine so usvojene in koliko), ampak tudi s procesi učenja: kako dijaki izbrane pojme razumejo, utemeljujejo, uporabljajo, analizirajo, vrednotijo, povezujejo, kritično presojajo; kako se znajdejo med različnimi viri in kako se izražajo. Razvijanje veščin kompleksnega mišljenja in spretnosti, ki so procesno naravnane ter povezane z vrednotami in miselnimi navadami posameznika, so tudi osnova za razumevanje trajnostnega razvoja. Gre za premik od objektivističnega h konstruktivističnemu učenju. Vse omenjene spremembe v izobraževanju zahtevajo tudi sistematično usposabljanje učiteljev na vseh ravneh izobraževanja.

Predmetna razvojna skupina za kemijo v gimnazijah skupaj z učitelji mentorji razvija strokovne podlage za uvajanje sprememb v pouk kemije, jih preizkuša v praksi in jih vokviru rednih izobraževanj ter partnerskega sodelovanja posreduje učiteljem in laborantom kemije v gimnazijah.

METODA

Posodabljanje pouka kemije v gimnazijskih programih se je sistematično pričelo že leta 2003 s projektoma Didaktična prenova in Evropski oddelki Zavoda RS za šolstvo. V okviru obeh projektov smo skupaj z učitelji kemije, ki so bili vključeni v projekt, analizirali obstoječe učne načrte za kemijo v gimnazijah (1998) in razvijali nove pristope ter učne situacije, ki v čim večji meri zagotavljajo učinkovito učenje kemije, kakovostno znanje in razvijanje samostojnega in ustvarjalnega mišljenja pri dijakih. Posodabljanje se je nadaljevalo z ustanovitvijo Predmetne komisije za posodabljanje učnih načrtov (2006), sestavljena je bila iz univerzitetnih učiteljev kadrovskih fakultet, učiteljev praktikov in svetovalcev Zavoda RS za šolstvo. Komisija je na osnovi pridobljenih rezultatov in spoznanj obeh projektov, spremljave pouka kemije v gimnazijah (ZRSŠ), analize tujih UN, mednarodnih raziskav in sodobnih trendov didaktike kemije, pripravila predlog posodobljenih UN za kemijo v gimnazijskih programih. Februarja 2008 je Strokovni svet RS za splošno izobraževanje sprejel posodobljena učna načrta za kemijo v gimnazijskih programih.

Sistematično uvajanje obeh učnih načrtov se je pričelo s prvimi letniki v šolskem letu 2008/09, v okviru projekta Ministrstva za šolstvo in šport, Evropskih strukturnih skladov in Zavoda RS za šolstvo, z imenom Posodobitev gimnazijskih programov, Predmetna komisija za posodobitev učnih načrtov je pridobila nove člane in se preoblikovala v Predmetno razvojno skupino za kemijo v gimnazijah (v nadaljevanju PRS za kemijo v gimnazijah). K sodelovanju je povabila 15 učiteljev mentorjev.

REZULTATI

V posodobljenem učnem načrtu je v ospredju uresničevanje razvijanja naravoslovno-matematične kompetence za razvoj kompleksnega in kritičnega mišljenja. Nekoliko je tudi spremenjen vrstni red posameznih vsebin, izpuščene so nekatere vsebine, ki so za srednješolsko raven prezahtevne ali jih obravnavajo pri drugih naravoslovnih predmetih. Dodane so nekatere vsebine, ki naj bi popestrile pouk kemije v smislu večjega povezovanja z življenjem. Posodobljen učni načrt zahteva tudi sistematično vpeljevanje submikroskopskih prikazov, to je zelo pomembno za lažjo razlago in napovedovanje pojavnega sveta snovi, pojavov in procesov na makroskopski ravni. Pri učenju kemije je pomembno, da učenci oz. dijaki razumejo in znajo povezovati pojme na vseh treh predstavnih ravneh (makroskopski, sub-mikroskopski in simbolni), kar predstavlja za mnoge učence in dijake veliko težavo. Poleg vsebinskih posodobitev posodobljeni učni načrt za kemijo zahteva izvajanje določenih učnih sklopov v obliki sodelovalno-projektnega oziroma eksperimentalno-raziskovalnega dela, ki temeljita na aktivnostih dijakov, učitelj pa pri tem postane usmerjevalec in organizator pouka in učenja.

Pri uvajanju novosti v pouk kemije, namenjamo veliko pozornost razvoju primerov dobre prakse, ki vključujejo zgoraj omenjene novosti iz učnega načrta. Učitelji mentorji v sodelovanju s člani PRS za kemijo v gimnazijah so v preteklem letu intenzivno uvajali te novosti v svoj pouk. Svoje izkušnje in spoznanja prenašajo na ostale učitelje v okviru rednih izobraževanj. Izšla bo tudi publikacija Posodobitve pouka kemije v gimnazijski praksi, ki bo učiteljem kemije v gimnazijah v pomoč pri iskanju njihovih lastnih poti udejanja ciljev posodobljenega učnega načrta za kemijo.

ZAKLJUČEK

V izobraževanju se morajo spremembe uvajati postopoma. Novi dokumenti in morebitne reforme niso dovolj. Resnična sprememba se zgodi šele z drugačnim razmišljanjem učiteljev, ki so pripravljeni sprejeti vlogo učitelja organizatorja in svetovalca namesto vloge prenašalca znanj. Ta pot pa zahteva intenzivno partnersko in procesno delo z učitelji, da bodo zmožni razumeti družbene spremembe, ki zahtevajo drugačen pouk, le tako bodo zmožni izobraževati in usmerjati dijake v uspešno življenje. Prvi koraki so narejeni, z učitelji kemije skupaj načrtujemo, iščemo rešitve, opazujemo, evalviramo in se na izkustven način učimo. Zgodba strokovnega in osebnega spreminjanja učiteljev kemije je izziv in odgovorna naloga PRS za kemijo v gimnazijah.

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POPULARISATION AND INCREASING OF INTEREST IN PHYSICS IN PAST YEARS AT CELJE FIRST GRAMMAR SCHOOL
/
POPULARIZACIJA IN POVEČANJE ZANIMANJA ZA FIZIKO V ZADNJIH LETIH NA I. GIMNAZIJI V CELJU

Nataša Ravnikar

I. gimnazija v Celju

natasa.ravnikar@guest.arnes.si

ABSTRACT

In this contribution, some activities performed in the field of physics at our school in recent years are presented. We are establishing that the above mentioned activities have contributed a lot to increasing of interest in this natural science area. One of the indicators of the increasing of interest and participating in physics is raising the number of candidates at physics as an optional subject at matura.

Keywords: *physics, activities, popularisation, increasing of interest*

UVOD

Na I. gimnaziji v Celju poleg rednega pouka fizike v zadnjih letih izvajamo nekatere dejavnosti, ki so prispevale k povečanju popularnosti fizike ter naravoslovja nasploh. Opažamo porast števila maturantov, ki se odločajo za izbiro fizike, več dijakov se udeležuje tekmovanj iz znanja fizike. Obenem na vseh področjih dosegajo tudi dobre rezultate. Povprečna ocena na maturi je okoli 4,0, v zadnjih letih sta dva dijaka naše šole rešila naloge na državnem tekmovanju iz fizike v celoti pravilno. V prispevku bodo predstavljene dejavnosti, s katerimi na šoli povečujemo interes na področju fizike.

METODA

Organizirali in izvedli smo strokovne ekskurzije v Ljubljano 2005 ob svetovnem letu fizike (na IJS, kjer nam je predaval tudi prof. dr. Janez Strnad, v HE), leta 2006 smo na Dunaju obiskali Tehniški muzej, 2007 v Muenchnu tehniški in letalski muzej ter rudnik soli pri Salzburgu in aprila 2009 v Švici raziskovali Znanstveni center v Winterthuru, popotovali po krajih, kjer je živel in delal Albert Einstein (Zurich, Bern) ter si v Cernu, Ženeva, ogledali "Anti-matter factory" ter kalorimeter Atlas. (Slika 1)

Slika 1: Fizikalna ekskurzija v Švico, Ženeva, Cern 3. 4. 2009

Fiziki aktivno sodelujemo pri aktivnostih Naravoslovnega društva I. gimnazije v Celju (http://naravoslovci.org/). Bili smo pionirji na tem področju in še pred ustanovitvijo organizirali zanimiva predavanja, med drugim predavanje dr. Marka Pleška o pospeševalnikih. Vsa leta izvajamo fizikalni in astronomski krožek z vsaj nekaj opazovanji letno. Pomladi 2008 smo sodelovali tudi pri pripravi verižnega eksperimenta v Tehniškem muzeju Slovenije. Vseskozi posodabljamo opremo, ki jo uporabljamo pri frontalnem pouku, kot tudi pri laboratorijskih vajah. Poleg redne uporabe interaktivne table in kamere na katedru, pogosto uporabljamo senzorje in vmesnike Vernier, trenutno 8 kompletov.

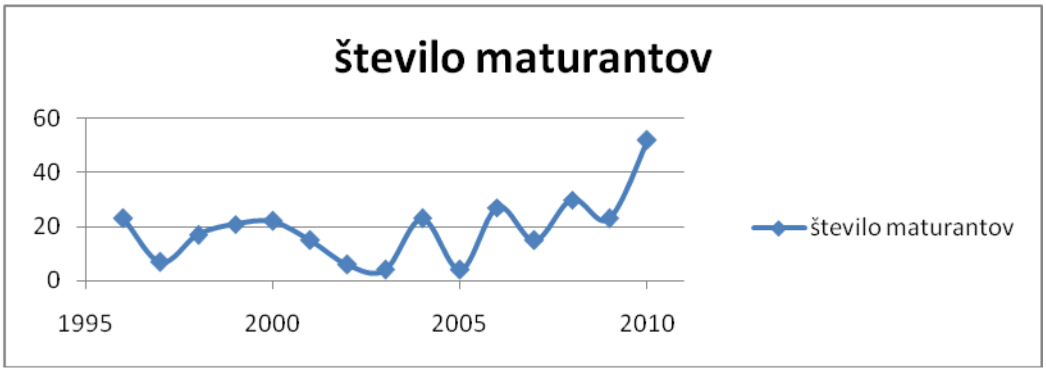
Hkrati v vsakdanje delo uvajamo moderne metode poučevanja kot so sodelovalno poučevanje profesorja in laboranta, timsko se povezujemo z drugimi predmetnimi področji (matematika, športna vzgoja, geografija), dijakom omogočamo vsakodnevno avtentično učenje, sodelovalno učenje, delo na terenu (določanje pretoka reke Savinje, povprečne hitrosti hoje, tekmovanje v vodoravnem metu ipd.). Učitelji fizike in laborant se redno izobražujemo tako v Sloveniji kot tujini. Izreden pomen vidimo v primernem odnosu do dijakov in njihovega dela. Pri vseh dejavnostih delujemo timsko in pomagamo drug drugemu pri organizaciji. Velik poudarek dajemo na sproščeno ozračje pri laboratorijskem delu.

REZULTATI

V zadnjih letih se je povečalo število dijakov, ki šolo zastopajo na regijskem tekmovanju iz znanja fizike. Točni podatki niso dosegljivi. Na državno tekmovanje se uvršča več dijakov kot v prejšnjem desetletju. Postopoma se je povečalo število dijakov, ki izberejo fiziko na maturi kot enega od izbirnih predmetov (Tabela 1, Grafikon 1).

Tabela 3: Število prijavljenih kandidatov na maturi iz fizike (vir: letna poročila in LDN šole)

Leto	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Število kandidatov	23	7	17	21	22	15	6	4	23	4	27	15	30	23	52



Grafikon 1: Število kandidatov na maturi iz fizike od leta 1996 do 2010

ZAKLJUČEK

V prihodnjih letih načrtujemo nadaljevati s temi dejavnostmi oziroma jih sproti dodajati. Pomembno je, da ohranimo in še zvišamo nivo znanja, ki ga dosežejo dijaki v gimnaziji. Veseli nas, da dijaki radi pridejo k uram fizike, da so sproščeni ob hkratnem pridobivanju konkretnih znanj, tako kot pri razvijanju naravoslovnih kot tudi splošnih kompetenc. Pomembno je, da v teh letih pridobijo izkušnje, ki jih bodo lahko koristno uporabili kasneje.

REFERENCE

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Letni delovni načrti I. gimnazije v Celju za omenjena šolska leta.

ENCOURAGING Technical CREATIVITY in the first class
/
Spodbujanje tehnične ustvarjalnosti v prvem razredu

Darja Rijavec

OŠ Ivana Roba Šempeter pri Gorici

darja.rijavec@gmail.com

ABSTRACT

The aim of this paper is to show how the author encouraged first-class pupils to develop technical creativity and cooperative learning. An example of project learning work is presented. Pupils made various decorative /ornamental and useful products from various natural and synthetic materials, using different tools and devices. Simultaneously with the course of the project, a research was carried out whose aim was to determine whether students have mastered the objectives of technical creativity/manual skills, provided by the first-class curriculum and whether they will improve graphomotorics.

Keywords: *project learning work, technical creativity, after school activities, the products.*

UVOD

Nadarjenost je potencial, lastnost, ki jo človek prejme ob rojstvu. Otrokova nadarjenost pa se redko sama po sebi izkazuje in razvija. Otroku je potrebno nuditi tako okolje, v katerem bo našel dovolj varnosti, spodbud in motivacije za njeno izkazovanje in razvijanje. Otrok lahko izraža svojo nadarjenost le preko dejavnosti, pri katerih je ustvarjalen. Nadarjenost ni nekaj dokončnega. Otrok, ki ima veliko priložnosti udeležbe v ustvarjalnih dejavnostih, bo svojo nadarjenost lahko neprestano razvijal. Strokovnjaki pravijo, da je idealno obdobje za odkrivanje in razvoj nadarjenosti, prav zgodnje otroštvo. Učitelj običajno prej opazi učence, ki so splošno nadarjeni, kot tiste, ki imajo nadarjenost povezano s praktičnimi sposobnostmi. Slednji pritegnejo pozornost le pri dejavnostih, ki so povezana z tehnično ustvarjalnostjo. V sodobnem gospodarstvu je za tehnični napredek ključnega pomena, dobro timsko sodelovanje. Če želimo učence usposobiti za potrebe sodobnega gospodarstva, jim moramo nuditi možnost sodelovanja pri dejavnostih, ki spodbujajo tehnično ustvarjalnost in sodelovalno učenje. Izbrati ustrezne dejavnosti s katerimi bo zadovoljil interes učencev in jih pritegnil k aktivnemu sodelovanju, je za učitelja zelo zahtevna naloga.

V nadaljevanju je prikazan primer projektnega učnega dela, katerega namen je bil spodbujanje tehnične ustvarjalnosti in sodelovalnega učenja pri prvošolcih.

METODA

Projektno učno delo je bilo izvedeno v času podaljšanega bivanja z učenci prvega razreda osnovne šole Ivana Roba Šempeter pri Gorici. Potekalo je dva meseca: od jesenskih do božično-novoletnih počitnic. Glede na čas izvajanja je bilo vsebinsko povezano s prazniki, ki se zvrstijo v prednovoletnem času. Namen projekta je bil razvijati izkustveno učenje, vzpodbujanje medsebojnega sodelovanja in razvijanje ter spodbujanje ustvarjalnih potencialov učencev na področju tehnike. Vzporedno z izdelovanjem izdelkov so učenci spoznavali jesenske in zimske praznike, ter povezanost izdelkov, ki so jih izdelali, s kulturno, versko in državno tradicijo.

Učenci so si ogledali nekaj različnih izdelkov vezanih na čas jesensko-zimskega obdobja. Njihova dovršena izdelava in ustvarjalne poslikave, so učence zelo očarale. Učiteljica jim je predlagala, da bi izvedli projekt, v katerem bi vsak učenec izdelal svoje izdelke. Nad predlogom so se učenci navdušili.

Skupaj z učiteljico so načrtovali skico projektnega dela. Med izdelovanjem skice so se učenci pogovarjali, izmenjevali ideje in mnenja ter dajali predloge za potek projekta. Učenci prvega razreda še ne znajo pisati, zato je skico napisala učiteljica na večji plakat, učenci pa so skico dopolnili z risbami, da bi si lažje zapomnili načrt dela. S skupno izdelanim načrtom, so si pomagali pri nadaljnjem izvajanju projekta.

Načrt je predvideval izdelavo treh med seboj tematsko različnih izdelkov: darila, voščilnice in obeske za božično drevo.

Učenci so se na začetku projekta razporedili v skupine, ki so ostale nespremenjene ves čas trajanja projekta. Vsaka skupina je enkrat tedensko dobila dve nalogi. Najprej je morala skupno izdelati določen izdelek: darilo, voščilnico ali obesek, nato pa so si tekom tedna izdelek izdelali vsi člani skupine. Delavnice so bile organizirane tako, da je vsaka skupina dobila zadostne količine najrazličnejših naravnih in umetnih gradiv in orodij za obdelavo ter načrt tehnologije izdelave izdelka po fazah. Vsak načrt za izdelek je bil razdeljen na stopnje s kratkim in jedrnatim navodilom za delo. Vsaki stopnji je bila dodana tudi fotografija, s katero so si učenci pomagali pri delu in tako potrebovali manj pomoči učitelja in so pri delu bili tako bolj samostojni. Branje načrtov, je eden pomembnih dejavnikov tehnične pismenosti. Pomembno pa je, da je načrt prilagojen starostni stopnji učencev.

Za izvedene delavnice je bila značilna barvitost in razigranost. Učenci so se nemoteno gibali po učilnici, si medsebojno pomagali in svetovali. Učiteljica ni skušala mladih ustvarjalcev vkalupljati v nek vnaprej zamišljen izdelek, ampak jih je spodbujala k lastni ustvarjalnosti. Učence je spodbujala k uresničitvi njihovih idej in jim, predvsem manj ustvarjalnim in spretnim, pomagala tudi njihove zamisli uresničevati.

Ob izdelovanju izdelkov, so učenci spoznavali lastnosti gradiv in pridobili izkušnje obdelave papirja, tanjšega kartona, Das mase, slanega testa, čebeljega voska, stekla, različnih semen in različnih vrst zdroba. Pri delu so uporabljali različno orodje in pripomočke: svinčnik, škarje, olfa nož, šablone, valj, modelčke za pecivo, lepilno pištolo ter tako pridobivali spretnost za rokovanje z njimi.

Sočasno s potekom projekta je bila izvedena tudi raziskava, katere namen je bil ugotoviti ali bodo učenci usvojili cilje s področja tehnike, ki jih predpisuje učni načrt prvega razreda in ali se jim bo izboljšala grafomotorika.

REZULTATI

V okviru projekta so bili v obdobju dveh mesecev, izdelani številni uporabni, simbolni in okrasni izdelki vezani na ta čas. Skupno je bilo izdelanih okrog sto izdelkov. Učenci so ob njihovem izdelovanju spontano spoznavali jesenske in zimske praznike, ter povezanost izdelkov s kulturno, versko in državno tradicijo. Med potekom projekta so učenci razvijali veselje do tehnično ustvarjalnega dela. Uporabljali in spoznavali so njim primerne materiale in orodja. Med praktičnim delom so krepili pozitivne osebnostne lastnosti: pripravljenost za sodelovanje, nudenje in sprejemanje pomoči, samopodobo, domišljijo, samokritičnost, delovne navade in čut za estetiko. Ob uporabi različnih gradiv, so spoznali njihove lastnosti. Rokovanje z različnimi orodji je pripomoglo k razvoju finomotorike rok in prstov.

Delavnice, ki so bile izvedene v okviru projekta, predstavljajo dober primer vzajemnega prenašanja znanja med učenci. Sodelovalno učenje v okviru delavnic se je izkazalo kot zelo dobra metoda za obravnavo žive teme – praznovanja, ki povezuje že sama po sebi. Tema se je izkazala kot otrokom zanimiva. Smotrnost učenja je bila zagotovljena, saj so bile izbrane vsebine in dejavnosti blizu otrokovim interesom. Zanje so bile pomembne, ker so jim pomagale pri razumevanju sveta, pojavov in odnosov v njem.

ZAKLJUČEK

Avtorica ugotavlja, da je projektno učno delo zelo primeren didaktičen sistem za delo v prvem razredu. Učenci so ob zaključku projekta bistveno bolje poznali lastnosti gradiv, orodij in pripomočkov za njihovo obdelavo. S svojimi besedami so znali opisati tehnološke korake pri izdelavi posameznih izdelkov. Postali so bolj spretni pri rokovanju z orodji in pri nekaterih tehnoloških postopkih: rezanju, valjanju, gubanju, prepogibanju, spenjanju, lepljenju... Pridobljene spretnosti so pripomogle k izboljšavi učenčeve grafomotorike in samozavesti ter posredno splošne uspešnosti. Izkušnja potrjuje, da bi bilo potrebno, tovrstno učenje in sodelovanje pogosteje umestiti v vzgojno-izobraževalni proces.

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HOW DO STUDENTS PERCEIVE SCIENCE AND TECHNOLOGY?
/
KAKO UČENCI DOJEMAJO NARAVOSLOVJE IN TEHNIKO?

Svein Sjøberg

University of Oslo, Norway

svein.sjoberg@ils.uio.no

Camilla Schreiner

University of Oslo, Norway

camilla.schreiner@ils.uio.no

ABSTRACT

ROSE is an international comparative study that investigates the diversity of interests, experiences, priorities, hopes and attitudes that children in different countries bring to school or have developed at school. The underlying hope is to stimulate an informed discussion on how to make science education more relevant and meaningful to students in ways that respect gender differences and cultural diversity. We also hope to shed light on how to stimulate interest in S&T-related studies and careers. ROSE has developed, after consultation with science educators from all continents, an instrument that tries to examine the attitudes of 15-year-old students. The ROSE instrument has around 250 single items – simply worded questions or statements requiring responses on a 4-point Likert scale. This enables the use of standard statistical methods like calculations of means and correlations. About 40000 students from 35 countries took part in ROSE, and about 10 PhD students from different countries will base their theses on ROSE data. Schreiner & Sjřberg (2004) report fully on the project rationale, development and logistics. Additional information, including reports on data collection from the participating countries, is available on the ROSE website. Several comparative articles and international reports have been published and more are planned.

UVOD

V mnogih visoko razvitih državah je opaziti občuten odklon v odločanju učencev za naravoslovje in tehniko (N&T). 'Evropa potrebuje več naravoslovcev' je naslov poročila Gibanja za povečanje humanističnih virov v naravoslovju in tehniki v Evropi (EC,2004). Poročilo obravnava stanje N&T v Evropski Uniji in posveča posebno pozornost številu ljudi, ki se odločajo za študij in zaposlitev na področju N&T. Naslov poročila razkriva bistvo: upad zanimanja za študij N&T je velik problem v večini držav Evropske Unije. Podobno težavo opažajo tudi v ZDA in večini drugih držav OECD.

Paradoks je, da večina evropskih gospodarstev, ki temelji na N&T, opaža pomanjkanje zanimanja za študij in zaposlovanje na področju N&T. Vse države pa se strinjajo glede pomembnosti visoko izobraženih in usposobljenih znanstvenikov. Ampak mladi ne izbirajo študija, ker bi to pripomoglo k domačemu gospodarstvu, njihova odločitev temelji na njihovih interesih, vrednotah in prioritetah. Očitno je, da odločanje za študij N&T ni več tako privlačno v bogatejših državah kot je to bilo pred desetletji.

Pomanjkanje interesa za N&T v šolah ni samo problem za gospodarstvo, ampak tudi grožnja za demokracijo, kajti večina odločitev v modernih družbah je odvisna od premislekov, ki vključujejo odločanje med znanstvenimi argumenti in vrednostnim sistemom. Naravoslovno nepismena množica ljudi lahko zlahka podleže propagandi v primeru volitev.

Zaradi naštetih razlogov je ključnega pomena razumeti težnjo N&T, prioritete in interese mladih: to so cilji projekta ROSE.

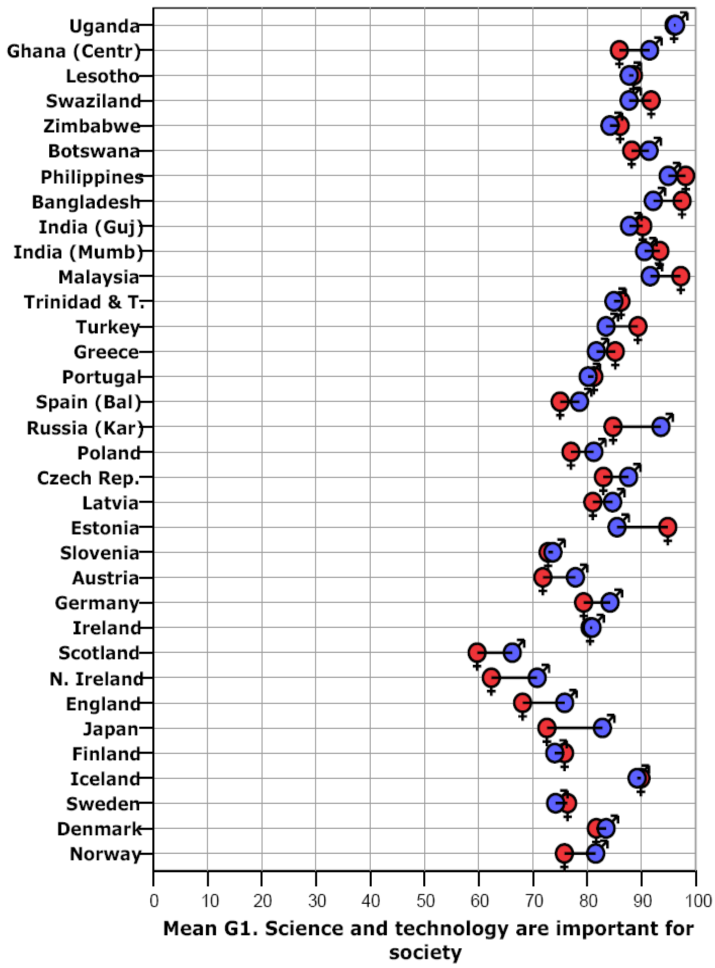
POZITIVNO DOJEMANJE NARAVOSLOVJA IN TEHNIKE V DRUŽBI

Kadar opazimo pomanjkanje zanimanja za študij in zaposlovanje na področju N&T v posamezni državi, najprej pomislimo, da imajo mladi negativen ali sovražen odnos do tega področja. Takšne trditve velikokrat slišimo v javnih razpravah. N&T sta kriva za večino zlega v modernih družbah, kot so onesnaževanje, uničevanje okolice, prekomerna poraba naravnih virov in celo konflikti. Ali res temelji odnos mladih na teh predpostavkah?

Veliko vprašanj v raziskavi ROSE daje luč na to temo. Rezultati nakazujejo, da ni splošne sovražnosti proti N&T med mladimi, niti v bogatih niti v revnejših državah. V splošnem je bilo podanih kar nekaj pozitivnih odgovorov:

- N&T sta pomembna za družbo
- Država potrebuje N&T
- N&T bosta našla zdravila za bolezni, kot so HIV/AIDS in rak
- Zaradi N&T bo več priložnosti za prihodnje generacije
- Zaradi N&T so naša življenja bolj zdrava, lažja in bolj udobna
- Nove tehnologije bodo omogočile bolj zanimive službe
- Prednosti N&T so večje kot škoda, ki jo lahko povzroči
- N&T bosta pomagala zmanjšati revščino in lakoto na svetu
- N&T povzročata večino okoljevarstvenih problemov

Večina učencev v večini držav (starih od 14-16 let) se strinja z zgoraj naštetimi trditvami, ne glede na to, da obstajajo zanimive razlike med državami ter med dečki in deklicami. V splošnem so dečki bolj pozitivno usmerjeni proti N&T (ali manj skeptični) kot deklice, prav tako so učenci v državah v razvoju bolj pozitivno usmerjeni kot učenci v bogatejših državah. Pomembno je, da je skupen odnos do N&T pozitiven.

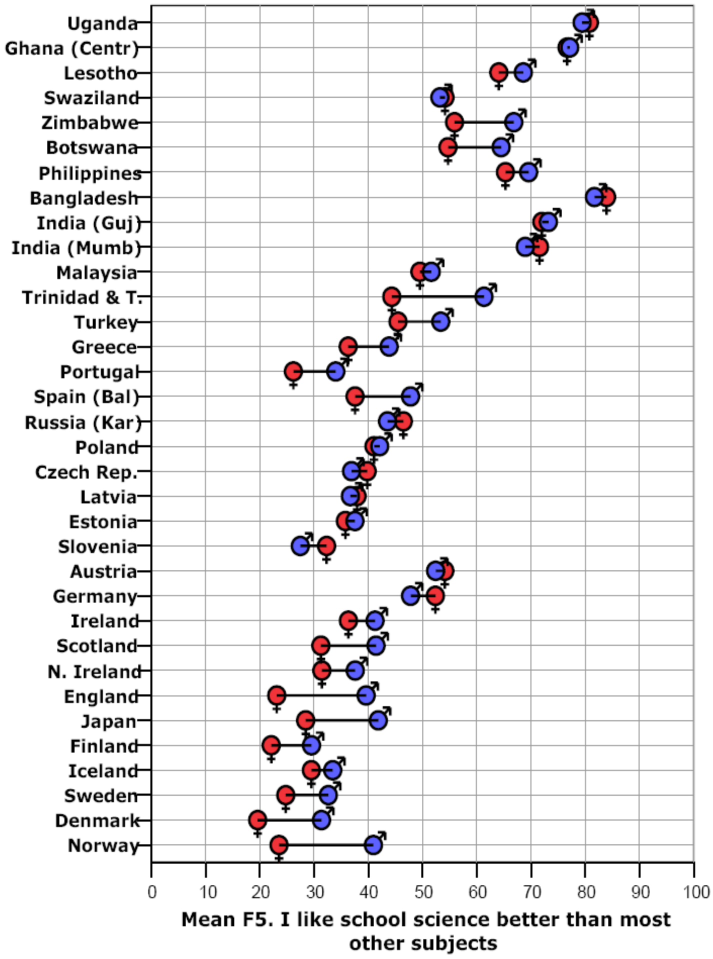


Slika 1: Naravoslovje in tehnika sta pomembna za družbo

Kot nam kaže Slika 1, deklice in dečki v vseh državah kažejo izrazito strinjanje s trditvijo, da sta naravoslovje in tehnika pomembna za družbo. Otroci v državah v razvoju se s to trditvijo bolj strinjajo, razlike med spoloma pa so zanemarljive

PROBLEMATIČEN ODNOS DO NARAVOSLOVJA IN TEHNIKE V ŠOLAH

Ne glede na to, da imajo učenci v vseh državah pozitiven odnos do vloge N&T v družbi, je odnos do N&T v konkretnih šolah različen.

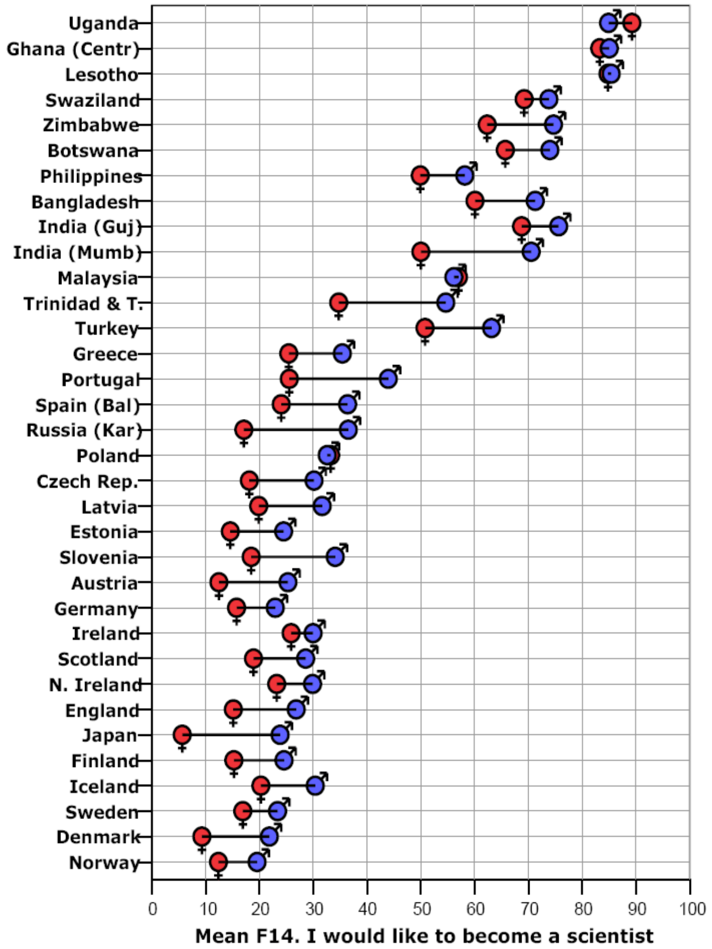


Slika 2: Raje imam naravoslovje kot druge šolske predmete

Slika 2 prikazuje velike razlike med učenci iz vseh koncev sveta glede njihovega odnosa do N&T. V splošnem imajo učenci v državah v razvoju radi N&T, medtem ko učenci v bogatejših delih sveta kažejo bolj negativen odnos. Opazimo lahko tudi velike razlike v spolu: v nekaterih državah deklice veliko bolj kot dečki zavračajo naravoslovje. Projekt ROSE vključuje tudi vprašanja o tem, kakšne koristi imajo učenci od naravoslovja v šoli, vendar za podrobno analizo tukaj ni prostora.

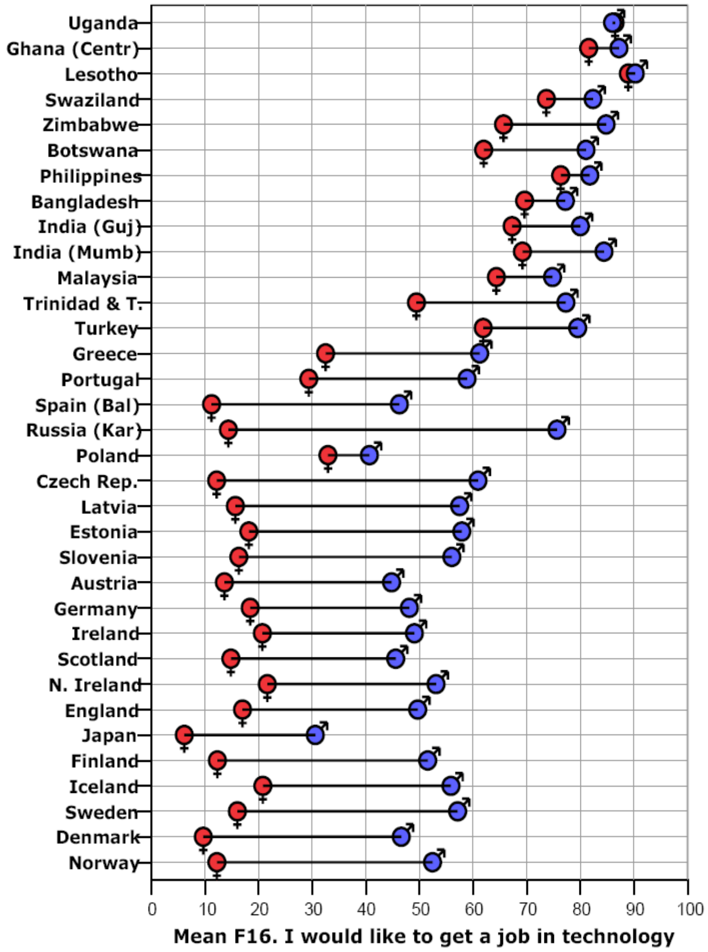
NENAKLONJENOST DO KARIERE V NARAVOSLOVJU IN TEHNIKI

Veliko vprašanj v projektu ROSE se nanaša na mlade in njihove poklicne želje. Tukaj predstavljamo le dva odgovora na preprosti vprašanji: ali učenec želi postati znanstvenik (Slika 3) in ali želi delati na področju tehnike (Slika 4).



Slika 3: Rad/-a bi postal/-a znanstvenik/-ca

Slika 3 nam prikazuje velike razlike med odgovori učencev iz bogatih držav in držav v razvoju. V slednjih imajo učenci veliko željo postati znanstveniki, medtem ko učenci iz držav OECD kažejo nenaklonjenost. Opazimo lahko tudi velike razlike v spolu, predvsem v državah OECD. V večini teh držav je bil povprečen odgovor deklic okrog 1,5 na 4-stopenjski lestvici, kar nam pove, da velika večina odklanja idejo, da bi postale znanstvenice.



Slika 4: Rad/-a bi se zaposlil/-a na področju tehnike

Slika 4 nam prikazuje podobno: zaposlitev na področju tehnike je veliko bolj privlačna za učence iz držav v razvoju kot iz bogatih držav. V razvitih, bogatih državah znaša povprečen odgovor za dečke okrog 2,5, medtem ko deklice kažejo izrazito negativen odnos. Vidimo tudi, da so dečki in deklice na Japonskem bolj negativno opredeljeni glede poklicne kariere s področja tehnike kot učenci iz drugih držav.

ZAKLJUČEK

Naš prispevek daje samo smernice in kratko informacijo glede projekta ROSE. Prikazujemo le štiri od 250 spremenljivk. Celotna študija je na voljo na naši spletni strani. Pred kratkim je bil predstavljen prvi doktorat, ki temelji na raziskavi ROSE (Schreiner, 2006), v katerem najdemo podrobno analizo o interesih mladih glede različnih področij naravoslovja in tehnike. Na podlagi te analize so predlagani tudi različni tipi učencev.

S projektom ROSE želimo spodbuditi razprave o pomembnosti N&T in njuni vlogi v izobraževanju in družbi. Raziskovalci iz različnih kulturnih ozadij so vključeni v samo raziskavo in razpravo. Mednarodno sodelovanje, mreženje in razvoj so ključnega pomena. Želimo si, da bi bilo izobraževanje iz N&T instrument ne samo za promocijo materialnega razvoja in blaginje, ampak tudi za razvoj osnovnih človekovih vrednot.

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www.ils.uio.no/english/rose

VOCATIONAL GUIDANCE AND WISHES OF PRIMARY SCHOOL LEARNERS REGARDING NATURAL SCIENCE LEARNING
/
POKLICNA ORIENTACIJA IN ŽELJE OSNOVNOŠOLCEV GLEDE UČENJA NARAVOSLOVJA

Drago Skurjeni

OŠ Destrnik-Trnovska vas

drago.skurjeni@guest.arnes.si

Slavko Dolinšek

Univerza na Primorskem, Fakulteta za management

slavko.dolinsek@guest.arnes.si

ABSTRACT

The purpose of this research paper is to investigate how interested primary school learners are in learning about natural topics within specific subject fields, and their wishes regarding future jobs and careers. Examining the existing lesson plans, it becomes evident that in grades one to nine natural topics are intertwined in different subject fields. A quantitative research has been performed in order to investigate the learners' wishes regarding learning about natural topics within different subject fields, the difference between the genders and their wishes regarding the profession. The data was acquired by means of a questionnaire. The findings suggest that in Slovenia the learners' interest in Natural science is minimal, nevertheless the girls are more interested than boys. The learners would like to learn more about the world of animals, non-scientific phenomena and information technology. However, they are not interested in physics. Regarding the choice of a profession, the findings suggest that in Slovenia the girls and boys are more interested in employments which will enable them to utilize their talents and abilities. They would like to work with people and make their own choices, and are not interested in working with tools and machines. The results are comparable to those in the western european countries.

Keywords: *curriculum, education, natural sciences, profession and career.*

UVOD

Že desetletje beležimo večanje vpisa na družboslovje in posledično relativno zmanjševanje le-tega na naravoslovnih in tehniških področjih. Vzrokov za to je veliko. Eden pomembnejših je, da so se morda spremenile vrednote mladih in posledično izbira poti izobraževanja, kariere ter načina življenja. Mladi imajo tudi različna in nejasna pričakovanja, kaj jih čaka po končanem izobraževanju. Svoj vpliv pa ima seveda tudi struktura gospodarstva in večanje števila delovnih mest v storitvenih dejavnostih. (Dolinšek idr. 2006).

S podobnimi „težavami” se srečujejo tudi v drugih državah Evrope. Vlade, pa tudi posamezne šole, poskušajo z različnimi pristopi povečati zanimanje za študij na področju naravoslovja in tehnike.

Bourdieu (1984, 144) omenja kolektivno razočaranje, ki izvira iz strukture neskladnosti med željami in resničnimi možnostmi, med družbeno identiteto, ki jo, kot se zdi, obljublja šolski sistem, ali identiteto, ki jo ponuja začasno, in družbeno identiteto, ki jo dejansko ponuja trg dela ter je vir nezadovoljstva z delom.

Mladi, pri katerih je družbeni sistem spodkopal družbeno identiteto in samopodobo, izobrazbeni sistem pa jih je odpravil z ničvrednim papirjem, ne najdejo druge poti ponovne vzpostavitve svoje osebne ter družbene integritete, kakor da vse odklanjajo.

V Sloveniji smo priča aktivnostim Ministrstva za visoko šolstvo, znanost in tehnologijo ter Ministrstva za delo, družino in socialne zadeve, ki poskušata ta gibanja obrniti predvsem z omejevanjem vpisa na družboslovne fakultete, še posebej poslovne in upravne.

Minister za visoko šolstvo, znanost in tehnologijo je v šolskem letu 2005/2006 obiskal vsa srednješolska središča z namenom, da bi osebno pripomogel k povečanju vpisa na fakultete z naravoslovnega področja. (Zupan 2005).

Takšnemu načinu prepričevanja in prizadevanjem ministra za visoko šolstvo, znanost in tehnologijo je oporekalo kar nekaj strokovnjakov.

Med drugim tudi dr. Krnel (2006, 6) poudarja, da so razvoju in posodobitvi pouka naravoslovja namenjene raznolike dejavnosti, a so učinki skromni. Razlog za te počasne in majhne premike je najbrž iskati prav v razdrobljenosti prizadevanj ter slabo opredeljenem cilju.

Krnel navaja: „Pogosto je že znotraj ene institucije delo neusklajeno in nepovezano. Večinoma je prepuščeno posamezniku, da se skozi svojo mrežo poznanstev in po svojih interesih razgleda po dejavnostih ter usmeritvah svojih kolegov na drugih področjih. Tako fiziki ne vedo, kaj razvijajo biologi, in ti ne vedo, kam se usmerjajo kemiki, vsi skupaj pa ne, kam težita skupna didaktika, teorija vzgoje in tako naprej." (Krnel 2006, 6).

Krnel (2006, 6) tudi pravi, da odločanje za naravoslovni študij ni odvisno le od uspešnosti propagande ministrstva za znanost in tehnologijo, temveč tudi od tega, kakšen je ter kakšen bo pouk naravoslovja v osnovnih in srednjih šolah.

Motiv za raziskavo v Sloveniji sloni na projektu ROSE („Razmišljanje, vrednote in prioritete mladih v povezavi z izobraževanjem na področju znanosti in tehnologij"), ki je nastal na podlagi študije SAS, katere nosilec je Svein Sjøberg in je bila pilotska študija projekta ROSE, ki ga je odobril raziskovalni svet na Norveškem. V projekt ROSE so preko mednarodnih raziskovalnih inštitucij: IOSTE, ESERA, in NARST povabili druge države. S projektom so seznanili tudi UNESCO. (Schreiner in Sjøberg, 2004).

Prve rezultate mednarodne raziskave ROSE oziroma prve primerjave med različnimi državami sta objavila nosilca raziskave. (Sjøberg, Schreiner, 2005). V članku so predstavili bistvo raziskave, podobnost med udeleženimi državami, povezava glede bodoče službe in usmeritev mladih.

Sjøberg ugotavlja, da je želja mladih po oblikovanju svoje kariere močno povezana s stopnjo razvoja določene države. V revnih državah je največji izziv povezan z izboljšanjem materialnih pogojev, ekonomsko rastjo, izboljšanjem zdravstvenega sistema ter s povečanjem blaginje. Razvoj družbe je glavna javno-politična tema in v tem pogledu sta znanost in tehnologija osnovni gonilni sili.

V letu 2006 je na podlagi obširnega zbiranja podatkov preko na ta način oblikovane mednarodne raziskave ROSE nastal (po besedah prof. Sjøberga) izredno kakovosten rezultat, doktorsko delo Camille Schreiner. (Schreiner, 2006).

Vzporedno s tem so raziskovalci znotraj projekta ROSE uporabili različne pristope vrednotenja rezultatov anket v nacionalnem okolju. Na podlagi tega je nastalo večje število objav. Največ rezultatov je bilo predstavljenih leta 2006 v okviru simpozija IAOSTE. V članku (Dolinšek, 2006) govori o krizi izobraževanja na področju študija tehnike v Sloveniji in EU.

Na Švedskem so v okviru raziskave definirali določene profile učencev, ki se nanašajo na njihovo zanimanje, poleg tega pa so predstavili tudi zanimivo nadaljevanje raziskave. (Oscarsson, 2006).

Finski predstavnik (Lavonen, 2006) je na podlagi uporabe faktorske analize predstavil raziskavo o tem, kako so karakteristike poklica pri učencih zadnjega razreda osnovne šole vezane na odločanje glede kariere. Zanimanje in poklicna usmeritev sta tesno povezani z učenjem ter izbiro kariere.

Rezultati iz Južne Afrike (Langenhoven, 2006) se nanašajo na raziskavo razlik med fanti in deklicami. Učenci južnoafriškega področja Western Cape kažejo pozitivno voljo za učenje šolske znanosti.

V Botsvani so naredili primerjavo med vrednotami učencev na srednjih šolah. (Yandila, 2006).

Glede dojemanja pomembnosti znanosti so rezultati pokazali, da učenci prepoznavajo pomembnost šolske znanosti za svoje življenje in bodočo kariero. Pokazali so, da cenijo znanost kot del svojega življenja in da bodo z učenjem znanosti dobili potrebne veščine ter znanja, ki jih potrebujejo, da bi se lahko spopadli z nenehno spreminjajočim se svetom.

Pri tem je potrebno omeniti še nekatere zanimive mednarodne primerjave, ena zadnjih je primerjava s Finsko. (Gaber, 2006).

V tem času je Finska s ponosom sprejela mednarodno potrditev (PISA 2000) uspešnosti svoje šole. Prej je dolgo veljalo, da pri reformiranju šolskega sistema naredijo »vse napake, ki jih naredijo Švedi, le da deset let pozneje«. Zdaj je njihov sistem »najboljši – najučinkovitejši« na svetu

NAMEN, CILJ IN TEZA RAZISKAVE

Skladno s predstavljenim raziskovalnim problemom smo definirali namen raziskave: ob naprej znanem metodološkem pristopu ugotoviti interes učencev devetih razredov osnovnih šol v Sloveniji za učenje vsebin naravoslovnih predmetov in želje glede bodoče službe ter kariere. Poleg tega želimo tudi opraviti primerjavo med osnovnošolskimi učnimi načrti (oziroma učnimi vsebinami) in ugotovitvami, pridobljenimi preko anketnih vprašanj (po metodologiji ROSE). Metodologija je podrobno predstavljena v publikaciji: „The Relevance of Science Education”. (http//www.ils.uio.no/english/rose/, 16. 2. 2007).

V Sloveniji do sedaj še ni raziskave, ki bi analizirala želje in prioritete mladih, povezane z izbiro šolanja ter s poklicno kariero. Glede na poznavanje objav in analiz s tega področja lahko govorimo, da je naša raziskava izvirna, saj bomo s pomočjo preverjene metodologije, prenesene v slovensko okolje, ugotovili želje učencev po učenju naravoslovnih vsebin in raziskali razlike med njihovimi željami glede na spol. Cilji, ki smo si jih postavili v raziskavi, so:

– Opraviti kritičen pregled ustreznih teoretičnih izhodišč in metodoloških pristopov s predlaganega področja.

– Ugotoviti, ali je pristop mednarodne raziskave ROSE ustrezen za izvedbo v slovenskem osnovnošolskem okolju.

– Prilagoditi metodološki pristop in izvesti anketiranje skladno s predlagano metodologijo.

– Ugotoviti interes učencev na področju vsebin naravoslovnih predmetov.

– Ugotoviti želje učencev glede bodoče službe in kariere.

Osnovna teza raziskave je: mladi se bolj odločajo za nadaljnje šolanje na področju družboslovja in njihove vrednote (oblikovane ob vsebinah osnovnošolskega izobraževanja, vplivih širšega družbenega okolja ter družbenih sprememb) niso prioritetno povezane z vsebinami izobraževanja ter s poklicem na področju naravoslovja in tehnike (znanosti in tehnologije).

METODA

Raziskava je bila opravljena na podlagi kvantitativne raziskave z uporabo anketnega vprašalnika zaprtega tipa, rezultati so analizirani z uporabo univariantne opisne statistike. V raziskavi smo uporabili pristop po mednarodnem projektu ROSE. Anketni vprašalnik, s katerim smo zbirali podatke, so v okviru mednarodne primerjalne raziskave ROSE razvili na Norveškem.

Osnovna oblika vprašalnika je v angleškem jeziku, razdeljen je na osem področij, sestavljajo ga zaprta in eno odprto vprašanje.

Vprašanja se nanašajo na interese učencev, odnose, načrte, poglede na znanost, tehnologijo, okoljevarstvene izzive itd. Pred uporabo vprašalnika v slovenskem prostoru so ga prevedli strokovnjaki (osnovnošolski profesorji angleščine).

Pri raziskavi ROSE v Sloveniji zasledujemo cilje, podane v predlogu mednarodne raziskave, in jih obenem navezujemo na specifične vsebine, ki se pojavljajo v okolju Slovenije, ter značilnosti našega izobraževalnega sistema. Za analizo zanimanja učencev na področju vsebin naravoslovnih predmetov smo rezultate ankete primerjali z učnimi vsebinami znotraj osnovnošolskih učnih načrtov.

Vprašalnik sestavlja deset sklopov vprašanj. Vse razen enega sestavljajo zaprta vprašanja. Pri zaprtih vprašanjih je uporabljena Likertova lestvica od 1 do 4. Ena pomeni popolno nestrinjanje, medtem ko pomeni štiri popolno strinjanje s trditvijo.

Odgovori se vrstijo v parih: se ne strinjam惘se strinjam, me ne zanima惘me zelo zanima, nepomembno惘zelo pomembno, nikoli惘vedno. Odprto vprašanje je sestavljeno iz dveh delov (prvi sprašuje, kaj bi radi delali kot znanstveniki, v drugem pa sprašuje po razlogih za to izbiro). Na področju z odprtim vprašanjem „Jaz kot znanstvenik” so učenci opisali, kaj bi radi delali kot znanstveniki in kaj bi radi raziskovali.

Vprašalnik so pred uporabo pregledali strokovnjaki (osnovnošolski profesorji) s posameznega predmetnega področja. Zaradi ugotavljanja razumevanja je bil vprašalnik pred uporabo preizkušen tudi na slovenskih osnovnošolcih. Odpravljeni so bili nerazumljivi pojmi, kar je zagotavljalo ustreznost raziskovalnega pristopa za Slovenijo.

Anketiranje se je izvajalo ob prisotnosti odgovorne osebe v šoli, kar je zagotovilo velik odstotek vrnjenih vprašalnikov.

Vprašalnik s katerim smo zbirali podatke, zajema osem področij z različnimi vprašanji. Področja so označena s črkami po abecednem vrstnem redu od A do J, izpuščena je črka Č:

— področje „Stvari, o katerih želim vedeti več” (108 vprašanj) se nahaja pod črkami A, C in E in zajema vprašanja, ki se nanašajo na predmetna področja z naravoslovnimi vsebinami, učenci pa se jih učijo v šoli,

— področje „Moj bodoči poklic” (26 vprašanj) pod črko B zajema vprašanja, ki sprašujejo o pomembnosti podatkov pri izbiri poklica,

— področje „Okoljevarstveni izzivi in jaz” (18 vprašanj) pod črko D zajema vprašanja o okoljevarstvenih izzivih,

— področje „Moje poznavanje znanosti” (naravoslovni predmeti, 16 vprašanj) pod črko F zajema področje naravoslovnih predmetov, o katerih se učijo v šoli,

— področje „Moje mnenje o znanosti in tehnologiji” (16 vprašanj) pod črko G pokriva področje znanosti in tehnologije,

— področje „Moje izvenšolske izkušnje” (61 vprašanj) pod črko H zajema trditve, ki se nanašajo na izvenšolske izkušnje,

— področje „Jaz kot znanstvenik” pod črko I zajema odprto vprašanje, ki sprašuje učence, kaj bi počeli kot znanstveniki in zakaj,

— področje „Koliko knjig imate doma” pod črko J sprašuje učence po številu knjig, ki jih imajo doma.

Camilla Schreiner in Svein Sjøberg (2004, 54—70) v priročniku „ROSE The Relevance of Science Education” pojasnjujeta posamezna področja v vprašalniku.

Ciljna populacija so bili učenci zaključnih razredov osnovne šole. Praviloma bi morali biti stari 14 let. Otroci, ki so bili zajeti v raziskavi, bi se naj rodili leta 1991. Razlike v letih se lahko pojavijo iz različnih vzrokov: mlajši od 14 let so lahko otroci, ki so se predčasno vpisali v šolo (zdaj so stari 13 let), starejši so tisti otroci, ki so razred ponavljali ali pa so se vpisali v šolo, ko so bili starejši od šestih let.

Za določanje vzorca smo izhajali iz načela, da je raziskava veljavna, če je opravljena na dovolj velikem vzorcu. Po metodologiji projekta ROSE je dovolj velik vzorec, če je v raziskavo vključenih vsaj 1000 učencev. Po podatkih MŠŠ je v deveti razred vpisanih 20.716

učencev, ki so razporejeni v 1004 oddelke, povprečno je v oddelku 20,6 učencev. V vzorec je bilo potrebno vključiti vsaj 60 ali 13,4 % šol, to pomeni, da je bilo v raziskavo vključenih 1236 učencev oziroma 5,9 % celotne populacije učencev. S predpostavko, da bomo dobili 80 % ustreznih odgovorov, je bilo v raziskavo vključenih 988 učencev. Šole so bile izbrane po načelu naključnega vzorčenja.

IZVEDBA

S formalnim dopisom Fakultete za management, Univerze v Kopru smo v februarju 2006 izbrane šole obvestili in jih povabili k sodelovanju. Vsak član projektne skupine je izvedel anketiranje na nekaj šolah, pred izvedbo ankete je zadolženi član projektne skupine vzpostavil telefonski stik s šolo. Tako smo dobili potrditev za sodelovanje oseminpetdeset šol, ravnatelja na dveh šolah sta izvedbi raziskave nasprotovala.

Šole so za izvedbo anketiranja odobrile eno šolsko uro (45 minut), na vsaki je bil nekdo določen za odgovorno osebo. Na posameznih šolah so odgovorni učitelji izvedbo v celoti prepustili članom projektne skupine. Z izvedbo raziskave smo pričeli 20. februarja, vse vprašalnike pa smo zbirali do 15. marca 2006. Po končanem anketiranju je vsak član zbrane vprašalnike svojih šol poslal na eno mesto, kjer so se podatki vnašali in pozneje obdelovali. Vsaki sodelujoči šoli smo priskrbeli tudi pisno gradivo o raziskavi in z ravnatelji opravili kratek intervju. Tako ravnatelji kot učenci so raziskavo vzeli resno. Učenci so vprašalnike reševali z zanimanjem, potreben čas za izpolnjevanje je bil v povprečju 20−40 minut. Časovne težave je imelo nekaj učencev, ki so slabše brali ali pa niso imeli dovolj koncentracije (opredeljeni kot učenci s posebnimi potrebami, te vprašalnike smo izločili iz raziskave).

Po opravljenem anketiranju smo ugotovili, da je bilo v vzorec zajetih 1187 učencev, kar je 96,03 % predvidenega vzorca ali 20,46 učenca na oddelek. V raziskavi je sodelovalo 537 dečkov in 547 deklic. Starost se je gibala od 13 do 16 let:

- 13 let: 7 učencev ali 0,58 % vzorca,
- 14 let: 853 učencev 71,6 % vzorca,
- 15 let: 214 učencev 18,02 % vzorca,
- 16 let: 8 učencev 0,67 % vzorca,
- 89 učencev ali 7,49 % vzorca iz neznanih razlogov ni bilo v šoli.

Iz analize smo 14 anketnih listov (1,17 % vzorca) izločili kot neveljavne (niso bili ustrezno izpolnjeni ali pa so učenci pustili prazne cele strani), kar pomeni, da je v raziskavi sodelovalo 1084 učencev oziroma da je bilo 91,32 % vprašalnikov iz celotnega vzorca veljavnih skladno z metodologijo, uporabljeno v raziskavi ROSE.

REZULTATI

Vprašalnik v poglavju „Stvari, o katerih želim vedeti več” zajema vprašanja, ki se nanašajo na zanimanje za učenje vsebin naravoslovnih predmetov, kot so: kemija, biologija, fizika, geografija, okoljska vzgoja, astronomija, biologija z botaniko, vzgoja za zdravje in vsebine, vezane na živalski svet. Znotraj predmetnih skupin osnovne šole se pojavijo tudi skupine splošnega značaja (znanost nasploh, mistični pojavi ...).

Vprašalnik je sestavljen tako, da učence sprašuje: „V kolikšni meri bi se radi učili o naslednjih vsebinah?”

Vprašanja se nahajajo pod črkami A, C in E in zajemajo 108 različnih trditev, na podlagi katerih ugotavljamo, katere so stvari, o katerih bi učenci želeli vedeti več.

Preglednica 1 prikazuje primerjavo povprečnih vrednosti odgovorov na vprašanja s področja „Stvari, o katerih želim vedeti več". Povprečne vrednosti se gibljejo znotraj intervala 1,62 in 3,17. Vrednosti, ki izstopajo od vrednosti 2,5 navzgor, pojasnjujejo stvari, o katerih želijo učenci vedeti več in jih zanimajo bolj kot stvari, ki padejo pod povprečje. Ocene pod 2,5 pojasnjujejo stvari, ki učence zanimajo malo ali pa sploh ne.

Preglednica 1: Posamezna vprašanja z najnižjimi in najvišjimi povprečnimi vrednostmi s področja „Stvari, o katerih želim vedeti več"

Zap. št.	Vprašanje	Skupaj	Deklice	Fantje
A40	Kako telovaditi, da obdržimo telo močno in v formi	3,17	3,28	3,06
A34	Občutek breztežnosti v vesolju	2,96	2,82	3,10
A23	Kako lahko meteorji, kometi ali asteroidi povzročijo katastrofe	2,96	2,93	3,02
A02	Kemikalije, njihove lastnosti in kako reagirajo	2,08	2,12	2,05
A15	Kako rastejo in se razmnožujejo rastline	1,94	2,02	1,86
A17	Kaj so atomi in molekule	1,91	1,95	1,86
C13	Zakaj sanjamo, ko spimo, kaj lahko pomenijo sanje	3,16	3,46	2,86
C08	Možnost življenja izven Zemlje	3,13	3,10	3,16
C07	Kako delujejo računalniki	3,05	2,70	3,38
C14	Duhovi in čarovnice – ali obstajajo	2,44	2,79	2,09
C12	Alternativno zdravljenje (akupunktura, homeopatija, joga) in njegov učinek	2,32	2,68	1,97
C01	Kako se surova nafta spremeni v druge materiale	1,85	1,56	2,14
E10	Kako nuditi prvo pomoč in uporabiti osnovno	3,06	3,23	2,88
E09	Spolno prenosljive bolezni in kako se zaščititi pred njimi	3,04	3,17	2,90
	Kaj vemo o HIV-u/AIDS-u in kako ga nadzirati	3,00	3,18	2,81
E19	Organsko in ekološko kmetovanje brez pesticidov ter fertilizatorjev	2,00	1,90	2,10
E33	Prednosti in možna tveganja oz. nevarnosti sodobnih metod kmetovanja kmetovanja	1,86	1,70	2,02
E01	Simetrale in vzorci na listih ter rožah	1,62	1,75	2,02

Učenci so pri odgovarjanju na vprašanja razvrščali odgovore na podlagi zanimivosti. Kljub temu da se lahko vprašanja iz vprašalnika združujejo v različne skupine, smo jih združevali po predmetih in vsebinah, zajetih v učnih načrtih za obvezne in izbirne predmete v slovenskih osnovnih šolah. Podlaga za združevanje vprašanj v predmetne skupine je bila primerjalna analiza učnih načrtov in vprašanj iz vprašalnika. Vsebine, ki jih je zajemalo posamezno vprašanje v vprašalniku, smo poiskali v posameznem učnem načrtu. Ker se vsa vprašanja ne nanašajo na učne vsebine, smo jih združevali po skupinah, ki so povezane med seboj (znanost nasploh, neznanstveno področje). Da smo vprašanja razvrstili v ustrezne predmetne skupine, so preverili in potrdili profesorji za posamezna predmetna področja.

Preglednica 2 prikazuje primerjavo vseh 12 predmetnih področij, ki smo jih oblikovali na podlagi analize učnih načrtov za naravoslovne predmete v osnovni šoli in vprašanj v vprašalniku iz projekta ROSE. Vsebine, ki se pojavljajo v raziskavi, se učenci učijo v šoli pri osnovnih in izbirnih predmetih ali področjih, ki niso vezana na določen predmet. Prikazana je primerjava povprečnih vrednosti posameznih predmetnih področij – skupaj in ločeno po spolu.

Iz preglednice 2 je razvidno, da učence najbolj zanima področje, ki opredeljuje mistične pojave (povp. = 2,83), sledi mu področje iz živalskega sveta (povp. = 2,74) in računalništvo ter informatika (povp. = 2,72). Zanimivo je, da učencev ne zanimajo fizika (povp. = 2,42), okoljska vzgoja (povp. = 2,38), kemija (povp. = 2,20) in rastline (povp. = 2,08).

Področja astronomija (povp. = 2,70), vzgoja za zdravje (povp. = 2,68), biologija človeka (povp. = 2,57, povp. fant. = 2,42, povp. dek. = 2,72), geografija (povp. = 2,47) in znanost nasploh (povp. = 2,44) so se po zanimanju učencev razvrstila v sredino lestvice. Iz analize povprečnih vrednosti področja znanosti nasploh lahko ugotavljamo, da fante znanost bolj zanima kot deklice, čeprav razlike niso velike (povp. fant. = 2,50, povp. dek. = 2,39).

V primerjavi med spoloma vidimo tudi, da so razlike med posameznimi področji minimalne. So pa področja, pri katerih so razlike izrazite: neznanstveni pojavi (povp. fant. = 2,62, povp. dek. = 3,04), računalništvo in informatika (povp. fant. = 3,07, povp. dek. = 2,38) in fizika (povp. fant. = 2,62, povp. dek. = 2,17). Razlike se pojavijo na podlagi interesa posamezne skupine učencev.

Če upoštevamo, da je vrednost 2,5 tista meja, ko govorimo, da učence določeno področje zanima (vrednost nad 2,5) in ne zanima (pod 2,5), lahko pri povprečni vrednosti 2,51 trdimo, da je zanimanje za naravoslovne vsebine v slovenskih osnovnih šolah na meji, ko govorimo, da učence naravoslovne vsebine zanimajo. Če primerjamo povprečno vrednost odgovorov deklic (povp. dek. = 2,5) z mejo zanimanja, ki prav tako znaša 2,5, ne moremo trditi, da deklice vsebine naravoslovja zanimajo ali da jih te vsebine ne zanimajo. V tem primeru bi lahko sklepali le za posamezna področja. Ugotavljamo lahko, da spadajo področja: neznanstveni (mistični) pojavi, živalski svet, računalništvo in informatika, astronomija, vzgoja za zdravje ter biologija človeka v področje zanimanja.

Področja: geografija, znanost nasploh, fizika, okoljska vzgoja, kemija in rastline ter človek pa spadajo v področje nezanimanja učencev za posamezna področja (vrednosti so pod 2,5).

Preglednica 2: Vrednosti po posameznih področjih skupaj in ločeno po spolu

Področje	Povp. skupaj	Povp. Fantje	Povp. Deklice
neznanstveni (mistični) pojavi	2,83	2,62	3,04
živalski svet	2,74	2,71	2,77
računalništvo in informatika	2,72	3,07	2,38
astronomija	2,70	2,82	2,59
vzgoja za zdravje	2,68	2,46	2,90
biologija človeka	2,57	2,42	2,72
geografija	2,47	2,48	2,47
znanost nasploh	2,44	2,50	2,39
fizika	2,42	2,67	2,17
okoljska vzgoja	2,38	2,43	2,33
kemija	2,20	2,25	2,16
rastline	2,08	2,07	2,09

Rezultati v preglednici 3, kjer so vprašanja iz sklopa „Moj bodoči poklic", v vprašalniku so pod črko B, merijo pa splošne interese v karakteristiki služb, so prikazani ločeno za deklice in fante.

Na podlagi povprečnih vrednosti s področja „Moj bodoči poklic", katerega podatki so pod črko B, ugotavljamo, da bi učenci, predvsem deklice, v svojem poklicu radi delali nekaj, kar je za posameznika pomembno in smiselno (B15 – povp. dek. = 3,71, povp. fant. = 3,40). Trditev B15 (Delati nekaj, kar je zame pomembno in smiselno) se je uvrstila na vrh povprečnih vrednosti v primerjavi za deklice. Takoj za trditvijo B15 (Delati nekaj, kar je zame pomembno in smiselno) se razporedi trditev B9 (Uporaba svojih talentov in sposobnosti – povp. dek. = 3,55, povp. fant. = 3,18). Ob primerjavi povprečnih vrednosti za fante ugotavljamo, da bi fantje najraje delali v poklicih, kjer bi lahko pomagali drugim ljudem, kar potrjuje trditev B2 (Pomoč drugim ljudem – povp. fant. = 3,54).

Drugo mesto po pomembnosti pri odločanju za poklic zaseda pri fantih trditev B17 (Imeti veliko časa za svojo družino – povp. fant. = 3,50). Fantje in deklice bi radi v svoji službi tudi veliko zaslužili, kar potrjujejo povprečne vrednosti pri trditvi B20 (Zaslužiti veliko denarja – povp. dek. = 3,33, povp. fant. = 3,33), ki so za obe skupini enake.

Zanimiva je ugotovitev, da so trditve: B24 (Postati šef v svoji službi), B22 (Postati slaven), B4 (Delo na področju zaščite okolja), B6 (Gradnja in popravilo predmetov z lastnimi rokami) ter B7 (Delo s stroji ali z orodji) na dnu vrednostne lestvice, gledano z osnove povprečnih vrednosti.

Pri vprašanju o delu s stroji in z orodji je pričakovano opazna največja razlika med spoloma v prid fantov (povp. fant. = 2,64, povp. dek. = 1,40). Na podlagi podanih podatkov lahko tudi ugotavljamo, da deklice ne želijo delati v poklicih, v katerih bi lahko uporabljale fizično moč in da je pri fantih želja po takšnih poklicih večja.

Preglednica 3: Povprečne vrednosti vprašanj področja B (Moj bodoči poklic)

Št.	Vprašanje	Sku.	Dek.	Fan.
B15	Delati nekaj, kar je zame pomembno in smiselno	3,55	3,71	3,39
B17	Imeti veliko časa za svojo družino	3,46	3,41	3,50
B20	Zaslužiti veliko denarja	3,43	3,33	3,54
B25	Razvijati in izboljševati svoja znanja in sposobnosti	3,39	3,42	3,36
B19	Delati na takšnem delovnem mestu, kjer se pogosto dogaja	3,38	3,46	3,30
B09	Uporaba svojih talentov in sposobnosti	3,36	3,54	3,18
B16	Delati nekaj, kar je v skladu z mojim prepričanjem	3,34	3,54	3,14
B13	Sprejemati svoje odločitve	3,30	3,5	3,12
B12	Imeti veliko časa za svoje prijatelje	3,30	3,30	3,29
B23	Imeti veliko časa za svoje konjičke, aktivnosti in interese	3,11	3,12	3,11
B14	Delovati neodvisno od drugih ljudi	3,06	3,22	2,90
B02	Pomoč drugim ljudem	3,04	3,31	2,77
B26	Delati kot del skupine z mnogimi ljudmi okoli sebe	2,99	3,11	2,87
B11	Predstavljanje novih idej	2,95	2,98	2,91
B01	Raje delam z ljudmi kot s stvarmi	2,85	3,19	2,51
B18	Delati nekaj, kar vključuje veliko potovanj	2,83	2,93	2,74
B10	Izdelovanje, oblikovanje ali izumljanje	2,82	2,72	2,91
B24	Postati »šef« v svoji službi	2,73	2,53	2,92
B21	Nadzorovati ostale ljudi	2,59	2,46	2,72
B03	Delo z živalmi	2,50	2,63	2,37
B22	Postati slaven	2,42	2,31	2,53
B08	Umetniško in ustvarjalno delo v umetnosti	2,38	2,67	2,11

B05	Delo z nečim lahkim in preprostim	2,34	2,29	2,38
B04	Delo na področju zaščite okolja	2,27	2,31	2,24
B06	Gradnja in popravilo predmetov z lastnimi rokami	2,07	1,63	2,50
B07	Delo s stroji ali z orodji	2,03	1,40	2,64

Iz rezultatov opisne statistike povprečnih vrednosti za področje F „Učenje o naravoslovju" (preglednica 4) lahko ugotavljamo, da se učenci s trditvijo F2 (Naravoslovje je zanimivo) strinjajo, kar dokazujejo povprečne vrednosti za omenjeno trditev (povp. = 2,86). Učenci pa se ne učijo naravoslovja samo zato, ker jim je zanimivo ampak tudi zato, ker menijo, da jim bo koristilo. To dokazujejo povprečne vrednosti za trditev F7 (Stvari, ki se jih v šoli naučim pri naravoslovju, mi bodo koristile v vsakdanjem življenju – povp. = 2,89). V primerjavi med spoloma je deklicam naravoslovje bolj zanimivo, prav tako pa dajejo deklice večji poudarek koristnosti naravoslovja kot fantje.

Iz rezultatov lahko ugotovim, da se tako fantje kot deklice ne strinjajo s trditvijo F6 (Mislim, da bi se v šoli morali vsi učiti o naravoslovju – povp. = 2,20), čeprav imajo deklice nekoliko bolj pozitiven odnos do naravoslovja kot fantje. Rezultati povprečnih vrednosti pri trditvi F1 (Naravoslovje je zahteven predmet) kažejo, da za učence naravoslovje ni zahteven predmet. Učenci z rezultati izkazujejo tudi, da naravoslovja nimajo najraje, kar se vidi pri trditvi F5 (Naravoslovje imam raje kot vse ostale predmete – povp. = 1,97) in da ga v šoli ne želijo veliko, kar je razvidno pri trditvi F15 (V šoli bi imel čim več naravoslovja – povp. = 1,90). Iz rezultatov povprečnih vrednosti (povp. = 2,16) za trditev F16 (Rad bi se zaposlil v poklicu, povezanem s tehnologijo) ugotavljamo, da učenci ne izkazujejo želje po poklicih, povezanih s tehnologijo. Če primerjamo rezultate povprečnih vrednosti ločeno po spolu za omenjeno trditev ugotavljamo, da fante, za razliko od deklic, zanimajo zaposlitve, povezane s tehnologijo (povp. fant. = 2,68, povp. dek. = 1,63).

Izhajajoč iz dejstev, da se osnovna šola zadnjih deset let spreminja, s tem posledično tudi učni načrti za posamezne predmete, učenci pa se glede na rezultate raziskave še vedno ne želijo učiti naravoslovnih vsebin, bo potrebno na področju naravoslovja poiskati dodatne rešitve za večje zanimanje učencev za te vsebine. To priložnost imajo strokovnjaki v Sloveniji že sedaj, ko se učni načrti ponovno posodabljajo.

Preglednica 4: Povprečne vrednosti področja F (Učenje o naravoslovju)

Št.	Vprašanja	Sku.	Dek.	Fan.
F7	Stvari, ki se jih v šoli naučim pri naravoslovju, mi bodo koristile	2,89	2,99	2,79
F2	Naravoslovje je zanimivo	2,86	2,99	2,73
F13	Naravoslovje me je naučilo, kako bolje skrbeti	2,70	2,83	2,58
F11	Naravoslovje je povzročilo, da bolj cenim naravo	2,68	2,79	2,57
F3	Naravoslovje je zame nezahtevno	2,68	2,76	2,59
F10	Naravoslovni predmeti so povečali mojo radovednost	2,57	2,65	2,48

F12	Naravoslovje me je naučilo o pomembnosti	2,52	2,56	2,47
F4	Naravoslovje mi je odprlo oči za nove in zanimive poklice	2,38	2,50	2,26
F8	Področja naravoslovja, o katerih se učim v šoli, bodo izboljšala	2,37	2,41	2,33
F1	Naravoslovje je zahteven predmet	2,29	2,29	2,3
F6	Mislim, da bi se v šoli morali vsi učiti o naravoslovju	2,19	2,30	2,08
F16	Rad bi se zaposlil v poklicu povezanim s tehnologijo	2,16	1,63	2,67
F5	Raje imam naravoslovje kot vse ostale predmete	1,97	2,03	1,90
F15	V šoli bi imel čim več naravoslovja	1,89	1,92	1,86
F9	Naravoslovni predmeti so vplivali na to, da sem kritičen	1,85	1,81	1,89
F14	Rad bi postal znanstvenik	1,84	1,66	2,03

Primerjava pri vprašanju B1 (Raje delam z ljudmi kot s stvarmi) nam kaže visoko zanimanje za delo z ljudmi v vseh primerjanih državah. Rezultati tudi kažejo, da je v vseh primerjanih državah delo z ljudmi zanimivejše za deklice kot za fante, saj so rezultati povprečnih vrednosti odgovorov deklic v vseh državah višji kot pri fantih. Ob primerjavi Slovenije z drugimi državami lahko ugotavljamo, da so rezultati v Sloveniji podobni kot v ostalih državah, le da so razlike med fanti in deklicami v manj razvitih državah manjše. V državi Malavi razlik v povprečnih vrednosti med fanti in deklicami skoraj ni, so pa najvišje med vsemi sodelujočimi državami.

Iz primerjave odgovorov na vprašanje B7 (Delo s stroji ali z orodji) je razvidno, da je zanimanje za delo z orodji zanimivo za otroke v nerazvitih državah, v evropskih pa se deloma za delo z orodji zanimajo le fantje. Deklic iz evropskih držav delo z orodji skorajda ne zanima. Deklice v Sloveniji so praktično najbolj nezainteresirane za delo z orodji. Ob primerjavi rezultatov povprečnih vrednosti odgovorov (ločeno po spolu) lahko ugotavljamo, da obstajajo v evropskih državah tudi velike razlike med spoloma. Zainteresiranost fantov za delo s stroji ali z orodji je večja kot pri deklicah.

Podobno kot v Sloveniji kažejo rezultati tudi na Danskem, Švedskem, Finskem in v ostalih evropskih državah. Delo s stroji ali z orodji najbolj zanima učence v državi Malavi, Ugandi in ostalih nerazvitih državah, vključenih v projekt ROSE.

Preglednica 5: Primerjava odgovorov na vprašanji B1 (Raje delam z ljudmi kot s stvarmi) in B7 (Delo s stroji ali z orordji) s področja B : Moj bodoči poklic

Država	Deklice	Fantje
Malawi	3,76	3,74
Greece	3,54	3,25
Poland	3,48	3,31

Država	Deklice	Fantje
Uganda	3,31	3,54
Philippines	3,18	3,35
Bangladesh	3,17	3,09

Uganda	3,42	3,32
Czech Rep.	3,35	2,67
Ireland	3,34	2,88
Lesotho	3,34	3,19
India (Gujarat)	3,33	3,03
Portugal	3,33	2,75
Philippines	3,32	3,17
Turkey	3,32	2,85
Russia (Karel)	3,30	2,77
Swaziland	3,29	3,04
Trinidad & T	3,28	2,85
Finland	3,26	2,69
Latvia	3,25	2,58
Bangladesh	3,22	3,03
N. Ireland	3,21	2,74
England	3,21	2,75
Iceland	3,20	2,63
Slovenija	3,20	2,52
Botswana	3,18	2,81
Zimbabwe	3,17	2,92
Japan	3,17	2,67
Israel (Hebr)	3,15	2,69
Spain (Balear)	3,13	2,91
Ghana (Centr)	3,11	3,01

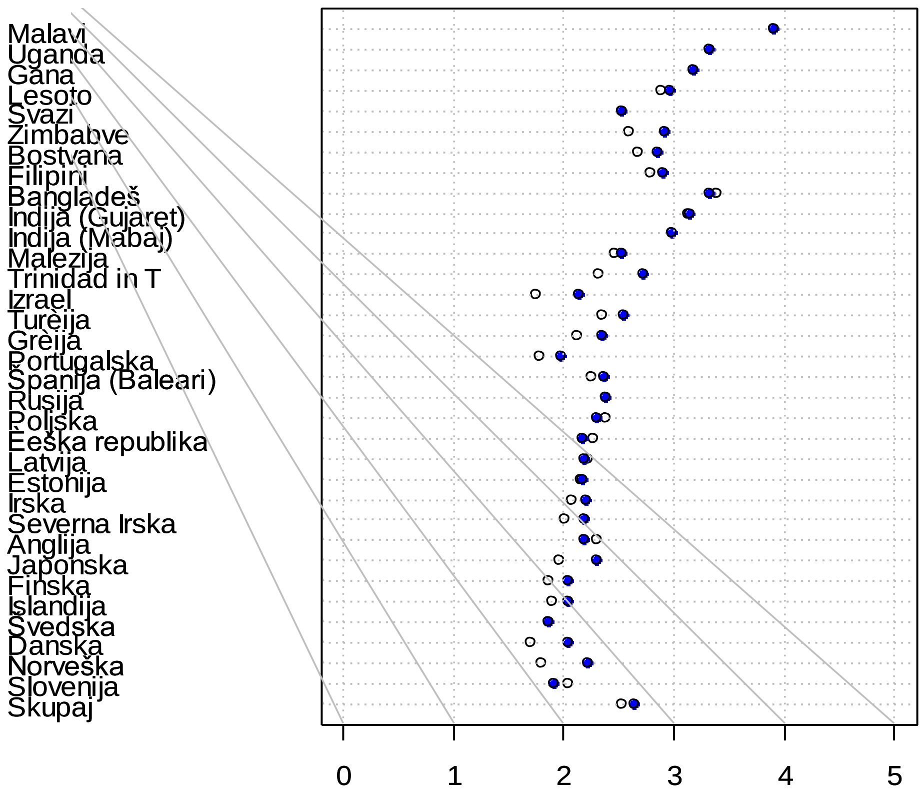
Lesotho	3,13	3,44
Ghana (Centr)	3,06	3,29
India (Gujarat)	2,91	3,04
Zimbabwe	2,72	3,24
India (Mumbai)	2,59	2,97
Swaziland	2,54	3,22
Malaysia	2,49	2,90
Botswana	2,47	3,15
Turkey	2,44	3,13
Japan	2,37	2,88
Trinidad & T	2,27	3,17
Poland	2,14	2,35
Ireland	1,86	2,72
Latvia	1,85	2,96
Czech Rep.	1,85	2,55
Greece	1,83	2,93
Israel (Hebr)	1,82	2,65
N. Ireland	1,82	2,80
Spain (Balear)	1,80	2,66
Estonia	1,76	2,55
Iceland	1,71	2,71
England	1,70	2,54
Portugal	1,69	2,53
Finland	1,68	2,64

Estonia	3,10	2,43
Sweden	3,03	2,25
Denmark	3,02	2,3
Norway	2,98	2,17
India (Mumbai)	2,91	2,68

Norway	1,56	2,69
Russia (Karel)	1,53	2,97
Sweden	1,50	2,54
Denmark	1,41	2,55
Slovenija	1,41	2,64

Primerjava pri vprašanju F5 (Naravoslovje imam raje kot vse ostale predmete) kaže, da učencev v razvitih državah naravoslovje ne zanima in da ga nimajo raje od drugih predmetov. Nasprotno se kaže v nerazvitih državah. Razlike med spoloma niso velike. Pri tej trditvi zelo izstopa država Malavi. V grafu (Slika 1) lahko opazimo minimalno odstopanje v povprečnih vrednostih. V večini držav so povprečne vrednosti fantov višje od povprečnih vrednosti deklic. Za razliko od večine držav imajo pri trditvi F5 (Naravoslovje imam raje kot vse ostale predmete) deklice v Sloveniji višje povprečne vrednosti od fantov.

Raje imam naravoslovje kot vse ostale predmete



Slika 1: Primerjava odgovora na vprašanje F5 (Raje imam naravoslovje kot vse ostale predmete) s področja F: Učenje o naravoslovju (fantje temno, deklice svetlo)

SKLEPNE UGOTOVITVE IN ZAKLJUČEK

Pri izvedbi raziskave smo sledili raziskovalnim ciljem in potrjevanju postavljene teze.

Ob pregledu teoretičnih izhodišč in metodoloških pristopov smo ugotovili, da je ponujeni pristop mednarodne raziskave ROSE ustrezen za izvedbo raziskave v slovenskem osnovnošolskem okolju. Ustreznost smo potrdili na osnovi poskusne uporabe vprašalnika na slovenskih osnovnošolcih.

Ugotovitve na podlagi povprečnih vrednosti odgovorov na vprašanja, razvrščena na posamezna predmetna področja v sklopu „Stvari, o katerih želim vedeti več", v vprašalniku pod črkami A, C in E, kažejo minimalno zanimanje učencev za učenje naravoslovnih vsebin pri posameznem predmetnem področju.

Na podlagi ugotovitev povprečnih vrednosti odgovorov na vprašanja lahko sklepamo, da se učenci ne želijo učiti vsebin, ki so zajete v predmetnih področjih fizike, okoljske vzgoje, kemije in rastlin.

Ugotavljamo, da se učenci v šoli ne želijo učiti naravoslovja saj ga nimajo raje kot ostalih predmetov. Rezultati raziskave in ugotovitve nam lahko vzbudijo dvom v pravilen izbor vsebin v učnih načrtih za posamezna predmetna področja.

Skladno z ostalimi cilji raziskave smo tudi ugotavljali: *„Kakšne so želje glede bodoče službe in kariere."*

Ob analizi rezultatov pri vprašanjih, ki se nanašajo na bodoči poklic, lahko ugotavljamo, da se v Sloveniji dekleta in fantje zanimajo za službo, v kateri bodo lahko uporabili svoje talente in sposobnosti. Radi bi delali z ljudmi in sprejemali svoje odločitve. Deklic delo z orodji in s stroji ne zanima. Pri tem vprašanju na področju B (Moj bodoči poklic) prihaja tudi do največjih razlik v povprečnih vrednostih odgovorov med fanti in deklicami.

Iz primerjave posameznih vprašanj med državami smo ugotovili, da se povprečne vrednosti odgovorov učencev v Sloveniji ne razlikujejo veliko od povprečnih vrednosti odgovorov učencev iz drugih držav v Evropi. Učence v nerazvitih državah naravoslovne vsebine bolj zanimajo kot učence v evropskih državah. Ugotovili smo tudi, da so razlike povprečnih vrednosti odgovorov med fanti in deklicami v Sloveniji podobne razlikam učencev v ostalih evropskih državah.

Ker raziskava zraven področja znanosti in tehnologije zajema še izkušnje učencev izven šole ter področje poklicnega odločanja, lahko dobljene rezultate uporabimo pri načrtovanju prihodnosti in oblikovanju šolske vizije.

Podatki, pridobljeni v raziskavi, in študij literature so nam odprli nova vprašanja ter dileme. Pripeljali so nas tudi do ugotovitev in priporočil, ne dovoljujejo pa sklepov, ki bi dali celovit odgovor na delovanje šolskega sistema oziroma na dileme o željah po učenju naravoslovnih vsebin.

Na podlagi rezultatov in ugotovitev mednarodne raziskave ROSE, da se učenci v Sloveniji ne želijo učiti naravoslovnih vsebin, odpiramo možnost nadaljnjih raziskav na nacionalni in internacionalni ravni, ki bi ugotavljale vzroke za takšno nezainteresiranost učencev za naravoslovne vsebine.

Ugotovitve so lahko tudi podlaga za analizo ustreznosti učnih vsebin znotraj učnih načrtov predmetnih skupin z naravoslovnimi vsebinami. Prav tako pa so lahko podlaga za spreminjanje kurikuluma. Ker je iz rezultatov razvidno, da se učenci ne želijo učiti naravoslovnih vsebin, radi pa bi več izvedeli s področij neznanstvenih pojavov, računalništva in astronomije, bi morda bilo vredno razmišljati v smeri „personaliziranega” kurikuluma.

Zanimivo bi bilo tudi:

惘ugotavljati kakšne so bistvene razlike med različnimi državami in kulturami ter

惘kako na odločanje mladih vplivajo oblika poučevanja, učni načrt in podobno,

惘 povezati rezultate projekta ROSE z drugimi raziskavami (TIMSS, PISA, Eurobarometer),

惘 na podlagi multi-variantne (faktorske) analize identificirati posamezne faktorje, ki vplivajo na odgovore,

惘 grupirati podatke ((cluster analysis) po vsebini (učni predmeti, regije, mesto − podeželje)),

惘narediti kvalitativno analizo tega, kako so anketiranci razumeli vprašanja.

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SCIENCE INSTRUCTION IN ELEMENTARY SCHOOL / POUK NARAVOSLOVJA V OSNOVNI ŠOLI

Mariza Skvarč
Zavod RS za šolstvo
mariza.skvarc@zrss.ai

Andreja Bačnik
Zavod RS za šolstvo
andreja.bacnik@zrss.si

ABSTRACT

The National Education Institute carried out monitoring of science instruction in grade 7 of elementary school in the academic year 2008/09. The methods employed were classroom observation, interviews with teachers and surveys involving teachers and learners. The findings show that syllabus goals are achieved satisfactorily and that the learners have positive attitudes towards science in this grade. Also, the instruction is a great deal based on active involvement of learners, such as experimental work. However, this kind of instruction is guided by teachers to a great extent. In the future teacher education should be focused on aspects of didactic differentiation and individualisation of instruction and on inquiry-based approaches to learning.

Keywords: *Teaching science, elementary school, experimental work, differentiated instruction*

UVOD

Zavod RS za šolstvo je spomladi 2009 na vzorcu tridesetih osnovnih šol izvajal spremljavo pouka pri izbranih predmetih v 7. razredu, med katerimi je bilo vključeno tudi naravoslovje. Pri tem je bil poseben poudarek na ugotavljanju: zastopanosti aktivnih metod dela pri pouku naravoslovja, s posebnim poudarkom na izvajanju eksperimentalnega dela; v kolikšni meri učitelji upoštevajo razlike med učenci z vključevanjem didaktične diferenciacije in individualizacije; s katerimi težavami se srečujejo učitelji pri poučevanju naravoslovja.

METODA

Spremljava je vključevala opazovanje pouka, intervjuje z učitelji, anketiranje učiteljev in anketiranje učencev. Pet opazovalcev je izvedlo trideset opazovanj pouka naravoslovja v 7. razredu na izbranih šolah. V tretjini primerov je opazovanje pouka naravoslovja trajalo dve šolski uri (blok ura). Anketni vprašalnik za učitelje naravoslovja je izpolnilo 39 učiteljev; poleg 30 učiteljev vključenih v opazovanje pouka, še 9 dodatnih učiteljev naravoslovja, ki poučujejo na šolah v spremljavi. Anketni vprašalnik o pouku naravoslovja je izpolnilo 177 učencev.

REZULTATI

Iz povprečnih ocen, dobljenih na osnovi izpolnjenih instrumentarijev ob opazovanju pouka, ki se gibljejo v razponu 3,8 – 4,4 (na lestvici 1-5), lahko sklepamo: da poteka pouk naravoslovja v spodbudnem delovnem vzdušju, da je pri pouku naravoslovja ustrezen poudarek na aktivnostih učencev in na raznolikih učnih oblikah, da imajo učenci dovolj priložnostih za izražanje mnenja in predstavitve svojega dela ter da dobijo ustrezne povratne informacije o svojem delu. Po oceni opazovalcev pouka je pouk v glavnem potekal v primerno opremljeni učilnica in ob ustrezni uporabi učnih pripomočkov. Slabše so opazovalci v povprečju ocenili spodbujanje učencev h kritičnemu razmišljanju (povprečna ocena 3). Pri opazovanih urah je bilo malo povezovanja pridobljenega znanja z vsebinami drugih predmetov (povprečna ocena pod 3), z najslabšo povprečno oceno pa je bila ocenjena diferenciacija in individualizacija dejavnosti in nalog.

V okviru opazovanja pouka naravoslovja je bil poseben poudarek namenjen zasnovi in izvedbi praktičnega oziroma eksperimentalnega dela pri pouku naravoslovja. Pri 40 % opazovanj, kjer je pouk vključeval praktično delo učencev, so opazovalci pouka ocenili ustreznost zasnove eksperimentalnih dejavnosti (ustrezen izbor dejavnosti/poskusa in primerno zasnovan delovni list…) s povprečno oceno 3,8, nekoliko slabše pa je bila ocenjena izvedba praktičnega oz. eksperimentalnega dela (povprečna ocean 3,2 na lestvici 1-5). Pri petih opazovanjih so opazovalci posebej poudarili, da je bila izvedba praktičnega dela preveč vodena in da je oblikovanje zaključkov opravil kar učitelj sam.

Iz rezultatov izpolnjenih anketnih vprašalnikov učencev lahko sklepamo (povprečne ocene v razponu 4,0 – 4,6 na lestvici 1 - 5), da se zdi učencem pouk naravoslovja zanimiv, razumljiv, koristen, da imajo naravoslovje radi in se pri pouku naravoslovja dobro počutijo. Poznajo kriterije ocenjevanja in menijo, da je njihovo znanje naravoslovja dobro. Pri pouku naravoslovja pogosto eksperimentirajo.

Nekoliko slabše (povprečne ocene v razponu 3 – 4) učenci ocenjujejo uporabo drugih virov (razen učbenika) pri pouku naravoslovja ter možnosti uporabe pridobljenega naravoslovnega znanja pri drugih predmetih. Najmanj (povprečna ocean 1,7 na lestvici 1 - 5) so se učenci strinjali s trditvijo, da dobijo večkrat drugačne naloge za reševanje kot ostali sošolci (diferenciacija). Pri domačih nalogah učenci ne potrebujejo veliko pomoči. 44 % učencev porabi tedensko doma za učenje in domače naloge iz naravoslovja manj kot eno uro, 39% učencev pa eno do dve uri časa.

Iz visokih povprečnih vrednosti stopnje strinjanja s posameznimi trditvami v anketnem vprašalniku za učitelje (razpon med 4,2 in 4,6 na lestvici 1-5) je razvidna ocena učiteljev, da pri pouku naravoslovja v veliki meri spodbujajo učence k samostojnemu delu, razvijanju kritičnega razmišljanja in da sistematično spremljajo delo in napredek učencev. Pri pouku naravoslovja učenci pogosto rešujejo praktične vaje in naloge. Učitelji uporabljajo ob učbeniku tudi druge vire (revije, slovarje, IKT).

Učitelji so v anketi podali povprečno oceno strinjanja med 3,5 in 4,0 z naslednjimi trditvami: da učenci pri pouku naravoslovja uporabljajo IKT, da učitelji redno izvajajo konzultacije z učenci in da je pouk naravoslovja v precejšnji meri individualiziran in diferenciran.

Iz anketnih vprašalnikov učiteljev lahko povzamemo, da se učitelji naravoslovja v veliki meri (povprečje 4,2 in več na lestvici 1 - 5) stalno strokovno izpopolnjujejo, sodelujejo v strokovnih aktivih na šoli in pri razvojnem delu šole. Na razpolago imajo dovolj strokovnega gradiva in vso potrebno podporo vodstva šole. Učitelji ocenjujejo (povprečje 4 na lestvici 1 - 5), da veljavni učni načrt predstavlja ustrezno podlago za kakovosten pouk naravoslovja, vendar je kakovostna in nemotena izvedba možna le v manjših oddelkih.

ZAKLJUČEK

Učitelji naravoslovja so zadovoljni z učnim načrtom za naravoslovje v 7. razredu in ne navajajo posebnih težav pri realizaciji ciljev predmeta naravoslovje v 7. razredu. Največ ovir, ki se odražajo na kakovosti pouka naravoslovja, pripisujejo slabim materialnim pogojem, neustrezni opremljenosti učilnice in neustrezno urejenemu laborantstvu.

Rezultati kažejo, da je pri pouku naravoslovja v osnovni šoli precejšen poudarek na aktivnostih učencev, zlasti na praktičnem (eksperimentalnem) delu. S tem tudi povezujemo pozitiven odnos učencev do predmeta. Čeprav so učitelji v anketi dobro ocenili svoja prizadevanja za diferenciran in individualiziran pristop pri pouku naravoslovja, pa vsi ostali rezultati (intervjuji, opazovanje pouka, ankete učencev) kažejo na to, da je prav to področje najbolj zapostavljeno.

Opazovanja pouka in intervjuji z učitelji so pokazali, da je eksperimentalno delo (praktični pouk) pogosto preveč vodeno izpeljano, da je le redko problemsko zasnovano in da bi učenci pri tovrstnih dejavnostih lahko imeli več priložnosti za raziskovanje in razvijanje višjih miselnih procesov.

Glede na priporočila in sodobne trende pri poučevanju naravoslovja bi se v bodoče veljalo usmeriti v vpeljevanje takšnih didaktičnih pristopov, da bi se v večji meri učenci učili naravoslovja z odkrivanjem in raziskovanjem ter imeli ob tem priložnosti za spoznavanje metodologije raziskovalnega dela in urjenje miselnih procesov in navad.

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Teaching genetics with multimedia results in better acquisition of knowledge and improvement in comprehension
/
POUČEVANJE GENETIKE Z MULTIMEDIJO IZBOLJŠA ZNANJE IN RAZUMEVANJE SNOVI

Petra Starbek

Srednja šola za farmacijo, kozmetiko in zdravstvo v Ljubljani

petra.starbek@gmail.com

Marjanca Starčič Erjavec

Univerza v Ljubljani, Biotehniška fakulteta

marjanca.starcic.erjavec@bf.uni-lj.si

Cirila Peklaj

Univerza v Ljubljani, Filozofska fakulteta

cirila.peklaj@ff.uni-lj.si

ABSTRACT

The goal of this study was to explore whether the use of multimedia in genetics instruction contributes more than other instructional modes to students' knowledge and comprehension. Four comparable groups of high school students were taught the process of protein synthesis: group 1 was taught only by reading text, group 2 by text supplemented with illustrations, group 3 in the traditional lecture format and group 4 through multimedia that integrated two short computer animations. Our findings lead to the conclusion that better learning outcomes can be obtained by the use of animations or at least illustrations when learning genetics.

Keywords: *multimedia learning, acquired knowledge, improvement of comprehension, retention of knowledge and comprehension.*

UVOD

Genetika je zelo povezana z vsakdanjim življenjem. Zato je pomembno, da dijaki znanja, ki jih pridobijo tekom učenja razumejo. Po besedah mnogih učencev pa je genetika, kljub temu, da je zelo zanimiva, tudi zelo zahtevna za učenje. S tem se strinja tudi veliko učiteljev, ki opažajo padec motivacije in slabo znanje učencev, ko pri pouku obravnavajo poglavja iz genetike. Učitelji nemalokrat priznajo, da imajo že s samim načinom poučevanja genetike težave. Zato smo v naši raziskavi testirali vpliv različnih načinov poučevanja sinteze beljakovin na znanje in razumevanje dijakov.

METODA

VZOREC

V raziskavi je bilo vključenih 468 dijakov 3. in 4. letnika dveh srednjih strokovnih šol in dveh gimnazij v Ljubljani. V vzorcu je bilo zajetih 193 moških (41.2 %) in 275 žensk (58.8%).

PRIPOMOČKI

Sestavili smo predtest znanja (ocena predznanja s področja zgradbe nukleinskih kislin in podvajanja DNK) in test znanja. Pripravili smo tudi učno enoto na temo sinteze beljakovin za štiri eksperimentalne skupine: za skupino dijakov, ki so se učili le z besedilom, za skupino dijakov, ki so se učili z besedilom in ustreznimi slikami, za učitelje, ki so poučevali dijake tekom klasične ure in za skupino dijakov, ki so se učili s pomočjo multimedije.

POTEK

Raziskava (izpeljana v šolskem letu 2007/2008) je obsegala štiri eksperimentalne ure v vsakem izbranem razredu. V prvi uri smo dijake seznanili z namenom in potekom raziskave ter rešili so predtest. Čez en teden so se dijaki najprej eno uro učili sinteze beljakovin v določenih pogojih (z besedilom, z besedilom in slikami, tekom klasične učne ure ali z multimedijo), zatem pa v drugi uri reševali test znanja (test 1). Četrta ura je bila izvedena po petih tednih, ko smo preverjali trajnost pridobljenega znanja in razumevanja sinteze beljakovin, dijaki so ponovno pisali test znanja (test 2).

ANALIZA PODATKOV

Podatke smo analizirali s pomočjo SPSS programa. Za analizo predtesta smo uporabili enosmerno analizo variance. Ker je analiza pokazala različnost predznanja dijakov posameznih ekaperimentalnih skupin, smo pri nadaljnji statistični obdelavi podatkov uporabili analizo kovariance (ANCOVA) in Bonferronijev Post Hoc test. Pri splošni primerjavi rezultatov testa 1 in testa 2 med eksperimentalnimi skupinami smo uporabili Repeated Measures ANCOVA. Primerjavo rezultatov test 1 in test 2 znotraj posamezne eksperimentalne skupine smo izvedli s T-testom.

REZULTATI

Najvišji uspeh na celotnem testu 1 so dosegli dijaki, ki so se učili z multimedijo in tisti, ki so se učili z besedilom in slikami, nižji uspeh so dosegli dijaki, ki so se učili tekom klasične ure in najnižji tisti, ki so se učili le z besedilom. Enake rezultate smo dobili pri analizi pridobljenega znanja. V primeru pridobljenega razumevanja pa se rezultati razlikujejo le v tem, da med dijaki, ki so se učili z multimedijo in tistimi, ki so se učili tekom klasične učne ure ni statistično pomembnih razlik. Vse ostale razlike so enake kot v primeru uspeha na celotnem testu 1 in v pridobljenem znanju.V primeru analize uspeha na testu 2 so statistično gledano najvišji uspeh dosegli dijaki, ki so se učili z multimedijo, nižji, dijaki, ki so se učili z besedilom in slikami in najnižji, dijaki, ki so se učili tekom klasične ure in dijaki, ki so se učili le z besedilom. V primeru analize trajnosti znanja so statistično gledano največ znanja na testu 2 pokazali dijaki, ki so se učili z multimedijo, nižje, dijaki, ki so se učili z besedilom in slikami ter dijaki, ki so se učili tekom klasične učne ure, najnižje znanje na testu 2 so pokazali dijaki, ki so se učili le z besedilom. V primeru analize trajnosti razumevanja so statistično gledano najvišje razumevanje na testu 2 pokazali dijaki, ki so se učili z multimedijo, in sicer v primerjavi z vsemi ostalimi dijaki, med katerimi pa ni statistično pomembnih razlik. Primerjava uspeha doseženega na testu 1 in testu 2 znotraj posameznih eksperimentalnih skupin je pokazala statistično pomemben upad uspeha, znanja in razumevanja, in sicer znotraj vseh eksperimentalnih skupin, razen znotraj skupine, ki se je učila le z besedilom. Tem dijakom so namreč njihove učiteljice biologije v času 5.-ih tednov do ponovnega merjenja uspeha še enkrat razložile celotno snov. Od tod porast uspeha na testu 2 v primerjavi s testom 1. Kljub temu pa je uspeh teh dijakov ostal med najnižjimi. Podrobnejša analiza z Bonferronijevm Pos Hoc testom je pokazala statistično pomembnost razlik le med nekaterimi eksperimentalnimi skupinami (Tabela 1).

Tabela 1: Rezultati Bonferronijevega Post Hoc testa primerjave eksperimentalnih skupin v rezultatih doseženih na celotnem testu 1 in testu 2, v znanju, razumevanju in njuni trajnosti

	Skupina[a]	MD (SE) p		Skupina[a]	MD (SE) p
Celotni test 1	M – K	4.45 (0.74)***	*Znanje*	M – K	3.85 (0.47)***
	M – B	11.80 (0.74)***		M – B	7.84 (0.46)***
	BS – K	5.43 (0.76)***		BS – K	3.90 (0.48)***
	BS – B	12.79 (0.72)***		BS – B	7.89 (0.46)***
	K – B	7.35 (0.75)***		K – B	3.99 (0.47)***
Razumevanje	BS – K	1.20 (0.35)**	*Celotni test 2*	M – BS	3.85 (0.92)***
	BS – B	4.89 (0.32)***		M – K	6.34 (0.91)***
	M – B	4.26 (0.34)***		M – B	7.29 (0.91)***
	K – B	3.69 (0.35)***		BS – K	2.49 (0.93) *
				BS – B	3.44 (0.88)***
Trajnost znanja	M – BS	2.89 (0.58)***	*Trajnost razumevanja*	M – BS	1.38 (0.41)**
	M – K	4.32 (0.58)***		M – K	1.98 (0.40)***
	M – B	5.71 (0.57)***		M – B	2.00 (0.41)***
	BS – B	2.82 (0.56)***			

MD, povprečje razlik; SE, standardna napaka; p, statistična pomembnost razlik: *** p<0.001, ** p<0.01, * p<0.05.

[a]Oznake eksperimentalnih skupin: B, besedilo; BS, besedilo s slikami, K, klasična ura; M, multimedija.

ZAKLJUČEK

Iz raziskave lahko sklenemo, da je uporaba multimedije ali vsaj slik ob besedilu pomembna pri učenju sinteze beljakovin, saj pripomore k večji pridobitvi znanja in razumevanja pa tudi njunemu ohranjanju.

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LEARNING ABOUT THE CHARACTERISTICS OF HALOGENS
/
SPOZNAVANJE LASTNOSTI HALOGENOV

Marinka Šipec

VIZ OŠ Bistrica ob Sotli

marinka.slogar@guest.arnes.si

ABSTRACT

In the article the essential benefits of using an interactive board as a tool for better teaching of chemistry in the primary school is provided. Emphasis is placed on the use of boards as a completely safe chemical laboratory. Dealing with new educational material on the halogen elements in the 8th class is presented.

Keywords: *the use of an interactive board, teaching chemistry in the primary school, halogen elements.*

UVOD

Interaktivna tabla je orodje, ki omogoča raziskovanje po medmrežju, dostop do datotek in programov na računalniku ter pisanje s svetlobnim črnilom. Njena prednost je zapomnitev vsega, kar je bilo na njej prikazanega, možnost prenosa le-tega na računalnik in uporaba pri naslednjih urah.

Najpomembnejše pri poučevanju kemije v OŠ je, da lahko tablo uporabimo kot popolnoma varen kemijski laboratorij, ki vsebuje veliko več opreme in kemikalij kot naši običajni laboratoriji. V njem lahko počnemo poskuse s kemikalijami, ki so ali preveč reaktivne ali preveč strupene, da bi jih lahko uporabljali v razredu. Pri teh poskusih ni strahu, da nam ne bi uspeli npr. zaradi prestare kemikalije. Seveda pa je prisotna tudi slabost, ki pa je včasih prednost, da ne moremo zaznati vonjav. Prednost je tudi, da ne nastajajo odpadne kemikalije in da nam po poskusih ne ostane kup umazane steklovine.

Poskus pripravimo enkrat, ga shranimo in ga nato lahko uporabimo za ponavljanje ter utrjevanje pri naslednjih urah, v več razredih in na voljo nam je več let.

Ti poskusi pa ne morejo in ne smejo zamenjati tistih, ki jih učitelji in učenci izvajamo s kemikalijami, ampak jih lahko nadgradijo. Poskuse najprej izvedemo v živo, nato pa prikažemo še enakega s programom za interaktivno tablo. Te poskuse lahko nadgradimo z natančnejšimi meritvami, izrisi grafa, prikazom enačb kemijskih reakcij v različnih oblikah ali s prikazom dogajanja na nivoju delcev.

METODA IN REZULTATI

Vsi halogeni elementi so strupeni. Fluor in klor sta pri sobni temperaturi zelo nevarna plina in pri vdihavanju poškodujeta dihalne poti. Klor in druge klorove spojine so v 1. svetovni vojni uporabljali kot bojni strup. Brom močno poškoduje kožo in rane se težko celijo. Jod je med halogenimi elementi najmanj strupen, zato jih z izjemo joda v šolskem kemijskem laboratoriju nimam.

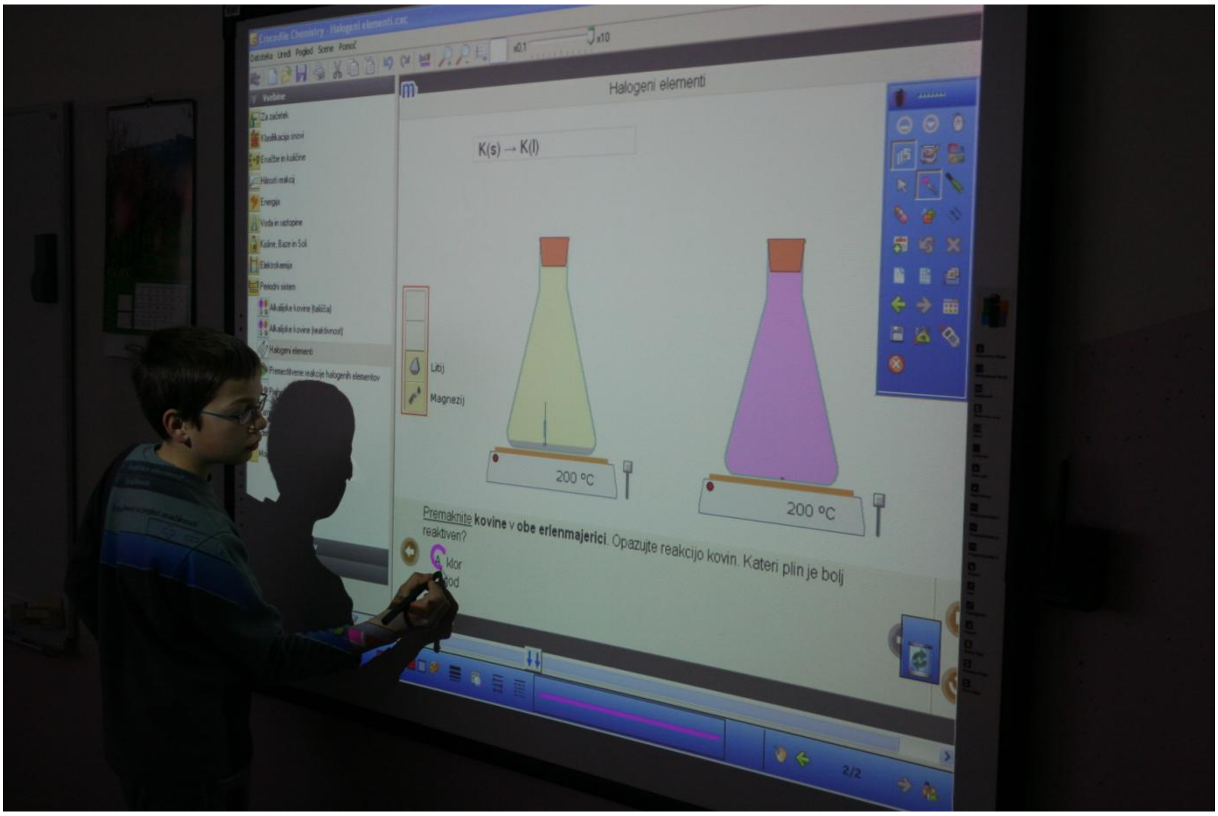
Zaradi prej navedenih vzrokov sem se odločila, da podam novo učno snov o halogenih elementih s pomočjo interaktivne table. Za pripravo te ure sem uporabila:

1. internetno stran http://www.osbos.si/e-kemija/e-gradivo/6-sklop/uporaba_halogenov.html,

2. aplikacijo programa crocodile chemistry periodni system:

   - halogeni elementi, ki prikazujejo reakcije kalija, natrija, litija in magnezija s klorom in jodom,
   - premestitvene reakcije halogenih elementov, ki prikazujejo reakcije spojin halogenih elementov

3. internetno stran http://www.osbos.si/e-kemija/e-gradivo/6-sklop/utrjevanje3.htm.



Slika 1: Uporaba interaktivne table

ZAKLJUČEK

Uporaba elektronske table mi je omogočila, da je bila učna ura zanimivejša, nazornejša in kvalitetnejša. Vsi učenci so mnenja, da se je pouk razlikoval od običajnega. Učenci si še želijo takega pouka, ker se jim zdi sodobnejši. Vendar so tudi pripomnili, da rajši gledajo poskuse v živo.

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CROSS-CURRICULAR CONNECTIONS IN SCIENCE: DESIRED GOAL OR REDUNDANT CATEGORY IN SYLLABI
/
MEDPREDMETNO POVEZOVANJE V NARAVOSLOVJU: ZAŽELEN CILJ ALI ODVEČNA RUBRIKA V UČNIH NAČRTIH

Andrej Šorgo

Univerza v Mariboru, Fakulteta za naravoslovje in matematiko

andrej.sorgo@uni-mb.si

ABSTRACT

Cross-curricular connections were one of the mayor goals of the 1998 school reform. Later, it was recognized that connections between subjects were vital mainly as a part of extracurricular activities and project work, but not in regular teaching in the classroom. On the basis of recognized problems, leading principles were prepared as a baseline for new syllabi in the year 2007. These leading principles are: teacher and school autonomy, approach of teaching-aiming and process-development, openness and selectivity (flexibility of the teaching process), competitive approach, quality of knowledge (immediacy, permanence and applicability of knowledge) and global approach of learning and teaching and encouraging curricular connections. But even if the intentions of the authors of curricular documents are clearly written, cross-curricular connections are one of the weakest points in Slovenian school system. The reasons are many: lack of strong autonomy, strictly subject-set syllabi, lack of such themes in textbooks and learning materials, and final examinations do not require cross- curricular integration. The contribution presents the possibility of interdisciplinary integration of science subjects based on the development of generic competences by using ICT.

Keywords: *Science, cross curricular connections, competences, information and communication technology*

UVOD

Pomembnejši cilj kurikularne prenove ob koncu prejšnjega stoletja je bilo medpredmetno povezovanje znanj ter pouk, ki bi se odlepil zgolj od akademskih vsebin. Nekaj let kasneje pa smo lahko ugotovili, da je bil ta cilj prenove uresničen v mnogo manjši meri, kot bi to bilo zaželeno (Rutar – Ilc, 2005, Šorgo in Šteblaj, 2007). Tako je bilo znanje, ki so ga učenci in dijaki pridobili še vedno vse preveč razdrobljeno in nepovezano, očitati pa mu je bilo mogoče tudi nizko stopnjo, s frontalnim delom, kot prevladujočo obliko in metodo dela, čeprav bi si dijaki pri pouku želeli predvsem aktivno delo ter čimveč laboratorijskehga in terenskega dela.

Približno deset let kasneje je bila sprožena prenova in posodobitev učnih načrtov. Načrtovana prenova gimnazijskega programa, ki je predvidevala tudi prerazporejanje ur pouka, pa je bila zaradi burnega odziva javnosti ustavljena. V prenovo se je krenilo na osnovi ključnih prepoznanih problemov zapisanih v dokumentu: »Smernice, načela in cilji posodabljanja učnih načrtov«, ki ga je pripravila Komisija za spremljanje in posodabljanje učnih načrtov in katalogov znanj za področje splošnega izobraževanja in splošno-izobraževalnih znanj v poklicnem izobraževanju (2007). Komisija je izoblikovala temeljna načela, na katerih naj bi temeljila prenova. Ta načela so bila:

- avtonomija učtelja in šole;
- jasna vodilna ideja predmeta;
- učno-ciljni in procesno-razvojni model pouka;
- odprtost in izbirnost (fleksibilnost učnega procesa);
- kompetenčnost;
- kakovost znanja;
- razvojno spremljanje učenčevih dosežkov in razvoj metakognitivnih sposobnosti;
- povezovanje predmetov in disciplin - globalni pristop, ki spodbuja »celostno« učenje in poučevanje.

Na osnovi teh smernic je bila nato sprožena posodobitev učnih načrtov, čeprav so posamezne predmetne skupine v resnici izvedle prenovo (Kalin, 2008). Delo po prenovljenih učnih načrtih, čeprav so bili pripravljeni za celo splošno-izobraževalno šolsko vertikalo, pa je steklo le v gimnazijskem programu, medtem ko je bilo uvajanje, zaradi ne povsem prepričljivih razlogov, v osnovne šole ustavljeno.

MEDPREDMETNO POVEZOVANJE V PRAKSI

Medpredmetno povezovanja po šolah poteka praviloma v obliki povezovanja povezovanje v okviru različnih dejavnosti, kot so projektni dnevi, naravoslovni tabori, ekskurzije, izbirne vsebine ipd., medtem ko je povezovanja, ki bi posegalo na nivo »vsakodnevnega« poučevanja, neprimerno manj. Zora Rutar Ilc (2005, str. 60) je na osnovi opazovanj pouka, ki so ga opravili svetovalci Zavoda RS za šolstvo ob spremljavi gimnazij, zapisala: *»Tudi na elemente medpredmetnega sodelovanja smo naleteli bolj po naključju; učitelji so v intervjujih povedali, da jim načrtno ponavadi ne posvečajo pozornosti in da se jim bolj »zgodijo«. Pojmovanja medpredmetnosti, ki so bila izpostavljena v intervjujih, tudi niso presegala idej o rutinskih korelacijah. Idej o medpredmetnih ali transdisciplinarnih projektih ni bilo.«*

Med pomembnejšimi vzroki za takšno stanje so: omejena krepka avtonomija učiteljev; ozko predmetno zastavljeni učni načrti; v učbenikih in gradivih skoraj ni medpredmetno obravnavanih tem; znanje, ki se preverja ob zaključku šolanja ne zahteva medpredmetnega povezovanja.

Šorgo in Šteblaj (2007) sta še v času priprav novih učnih načrtov zapisala: *"Medpredmetnega sodelovanja, kot zaželenega cilja kurikularne prenove, ni bilo mogoče doseči le s prenosom odgovornosti zanj na učitelje po šolah. Zato predlagamo, da se pri prenovi gimnazijskega programa težišče medpredmetnega sodelovanja z organizacijskega prenese na vsebinski in didaktični nivo, kjer pa ključno vlogo igrajo učni načrti. Učne načrte je potrebno že v fazi nastajanja uskladiti na način, ki bo omogočil fleksibilnost in avtonomijo učiteljem na posamezni šoli. S tem bi na institucionalni ravni omogočili medpredmetno povezovanje in aktiviranje učiteljeve in dijakove kreativnosti.*" Ob analizi prenovljenih učnih načrtov lahko ugotovimo, da nasvet kasneje ni bil upoštevan.

Načeloma je z malo domišljije in nekaj akrobacijami v razmišljanju možno poiskati in tudi najti povezave med dvema ali več poljubnimi vsebinami katerihkoli predmetov, čeprav se lahko zdijo neodvisnemu opazovalcu takšne povezave prisiljene. Je pa povsem nerazumljivo, da ostajajo nepovezani »naravni« sklopi predmetov, kot so fizika, kemija in biologija, saj so v bistvu le trije nivoji razlage dogajanj v naravi.

Za medpredmetno povezovanje sta ustrezna predvsem dva načina. V prvem primeru izberemo ustrezno vsebino, ki jo nato proučujemo iz različnih zornih kotov. V drugem primeru pa izberemo skupno metodo, ki jo nato uporabimo pri obravnavi različnih vsebin. V vsakodnevni praksi je največ težav s povezovanjem vsebin, ki se sicer obravnavajo pri različnih predmetih, a v različnih časovnih obdobjih in iz različnih aspektov (npr. ekološke vsebine). Iluzija je pričakovati, da bi lahko vse vsebine, ki jih je moč medpredmetno povezati, časovno tudi povsem uskladili, saj ima vsak predmet, kakor tudi zaokroženo poglavje znotraj predmeta, svojo notranjo logiko, ki je ni mogoče povsem prezreti. Praktiki po šolah praviloma razrešujejo ta problem na način, da izbrano vsebino po medsebojnem dogovoru sodelujočih učiteljev izvedejo izven ur rednega pouka po urniku, najpogosteje v sklopu izbirnih vsebin. Žal na ta način ostane večina vsebin med predmeti nepovezana, iskanje povezav pa prepuščeno posameznim učiteljem ali celo dijakom.

Za povezovanje vsebin v sklopu rednega pouka bi lahko bil ustreznejši drugi pristop, kjer bi snov sicer obravnavali pri različnih predmetih v različnem časovnem obdobju, »lepilo« pa bi predstavljale uporabljene metode in poudarki, ki bi napeljevali k medpredmetnemu povezovanju in transferu znanj med različnimi predmeti. Prednost metode, kot povezovalnega elementa med predmeti je, da metoda ni vezana na časovne okvire, zato jo je mogoče uporabiti neodvisno od časovne umeščenosti vsebine v učni načrt posameznega predmeta. Ena od možnih stičnih točk med predmeti, ki bi lahko povečale transfer znanj med njimi, je računalniško podprt laboratorij, kar se je izkazalo tudi že v praksi. S pomočjo enake metode dela je bilo mogoče preseči prepad ne le med predmeti, temveč celo med različnimi tipi šol.

GENERIČNE KOMPETENCE: LEPILO MEDPREDMETNEGA POVEZOVANJA

V zadnjih letih so pozornost strokovne javnosti pritegnile kompetence, opredeljene v evropskem referenčnega okvira (Uradni list Evropske unije L 394/13), kot kombinacija znanja, spretnosti in odnosov, ustrezajočih okoliščinam. Medtem, ko so ključne kompetence preveč splošne, da bi jih bilo mogoče uporabiti za operacionalizacijo medpredmetnega povezovanja, pa temu ni tako z generičnimi (transverzalnimi) kompetencami, saj so predmetno neodvisne.V projektu »Razvoj naravoslovnih kompetenc« smo na osnovi Meyerjevega poročila zasnovali naslednjo listo generičnih kompetenc, ki jih posameznik bolj kot s specifičnim učenjem določene snovi razvija z načinom dela. Kompetence na katerih smo zasnovali delo v projektu so:

- sposobnost zbiranja informacij,
- sposobnost analize in organizacija informacij,
- sposobnost interpretacije,
- sposobnost sinteze zaključkov,
- sposobnost učenja in reševanja problemov,
- prenos teorije v prakso,
- uporaba matematičnih idej in tehnik,
- prilagajanje novim situacijam,

- skrb za kakovost,
- sposobnost samostojnega in timskega dela,
- organiziranje in načrtovanje dela,
- verbalna in pisna komunikacija,
- medosebna interakcija ter
- varnost pri delu.

Ob preverjanju gradiv, zasnovanih na kompetenčnem pristopu, se je izkazalo, da so bile še posebej učinkovite so bile povezave, ki so vključevale še uporabo informacijske in komunikacijske tehnologije.

Predmetno-specifične kompetence – so kompetence, specifične za vsako posamezno strokovno-znanstveno področje, npr. za kemijo, matematiko, fiziko, biologijo, itn. ter za medpredmetno povezovanje manj primerne.

SKLEP

Ob branju prenovljenih učnih načrtov lahko ponovno ugotovimo, da so prav ti en od temeljnih vzrokov za pomanjkljive medpredmetne povezave. Na njihovi osnovi so namreč napisani učbeniki, maturitetni katalogi ter iz njih izhajajoča nacionalna preverjanja znanja in matura. In kar se ne preverja in ocenjuje, je v šolah žal obsojeno na životarjenje. Upanje nam pa dajejo posamezni učitelji, ki so sposobni preseči prepade med predmeti v dobro svojih učencev in dijakov.

ZAHVALA

Delo je bilo izvedeno na Fakulteti za naravoslovje in matematiko Univerze v Mariboru kot del projekta Razvoj naravoslovnih kompetenc. Projekt sofinancirata Ministrstvo za šolstvo in šport Republike Slovenije ter Evropski socialni sklad.

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THE WATER CYCLE
/
KROŽENJE VODE

Asja Štucin

OŠ Tržič

asja.stucin@gmail.com

ABSTRACT

What circulates and what changes is one of the thematic components at a school subject Science and technology in 5th class. Basic standards require knowledge and understanding of the circulation of water in nature and the importance of rotation for balance in nature. The preferred method to attain these teaching aims seemed a role play to me. I proposed to play a game of the circulation of water to my students. The play lasted for about 15 minutes then the questions for consolidating learning materials followed. Such method covers all learning processes: verification of previous knowledge, reading new teaching materials and consolidating knowledge. Science contents (water circulation) were articulated with engineering (construction costumes).

Keywords: *water cycle, role play, costumes, concrete learning methods*

UVOD

V šolskem letu 2008/09 sem poučevala predmet naravoslovje in tehnika v 5. razredu na Podružnični šoli v Lomu pod Storžičem. V oddelku je bilo samo 10 učencev in učenk. Eden izmed vsebinskih sklopov tega predmeta je tudi Kaj kroži in kaj se spreminja. Temeljni standardi, ki jih morajo učenci doseči zahtevajo poznavanje in razumevanje kroženja vode v naravi in pomen kroženja za ravnotežje v naravi. Operativni cilji so bolj konkretni. Razumeti morajo procese pri kroženju vode: spreminjanje temperatur, agregatnega stanja in gibanje; razumeti stekanje tekoče vode proti morju, ki je največji zbiralnik vode; razlikovati med površinskimi vodami in podtalnicami ter spoznati pomen podtalnice kot vira pitne vode. Veliko zahtevnih in dokaj nepredstavljivih ciljev za učence v petem razredu, ki so stari okrog 10 let.

METODA

Razmišljala sem, s katerimi učnimi metodami in oblikami bi jim to učno snov najlažje predstavila. Igra vlog se mi je zdela najprimernejša. Učencem sem predlagala, da bi zaigrali igrico o kroženju vode. Želela sem, da sami napišejo scenarij, sami izdelajo kustume in si izberejo glasbeno ozadje. Z navdušenjem smo se lotili dela. Ena izmed učenk je odlično napisala besedilo, vloge sem podelila prav vsem učencem, kustume pa smo izdelali kar v šoli. Iz debele pene smo izrezali 5 velikih kapljic, jih pobarvali z modro barvo in nanje namestili elastike. Podobno smo naredili dva oblaka, le pobarvali smo ju s sivo barvo. Sonce smo ravno tako izrezali iz pene in ga pobarvali rumeno. Učenka si ga je namestila na glavo. Dve dekleti, ki sta igrali rožici pa sta se oblekli v zelena oblačila na glavo pa sta si nadeli klobuk v obliki cvetnih listov. Tudi glasbo smo izbrali skupaj, upoštevala sem njihove predloge, saj sem želela, da se med igranjem počutijo sproščeno. Igrica je bila dolga okrog

15 minut, potem pa so sledila vprašanja za utrjevanje učne snovi o kroženju vode. Vsi so morali poznati svojo vlogo in vloge drugih učencev in znati razložiti pomen vseh likov v igrici.

REZULTATI

Učno uro Kroženje vode so učenci POŠ Lom pod Storžičem predstavili študentom Pedagoške fakultete iz Maribora in učencem 5. razreda OŠ Tržič. Na ta način smo prikazali enega izmed možnih pristopov do razumevanja načrtovanih učnih vsebin. Študentje so pokazali velik interes in bili presenečeni nad samostojnostjo in originalnostjo učencev.

ZAKLJUČEK

Menim, da je bila tovrstna metoda za obravnavo omenjene učne snovi odlično izbrana, saj je zajela vse učne procese: od preverjanja predznanja, obravnave nove učne snovi in utrjevanja znanja. Hkrati so bile tudi učne oblike med seboj prepletene; od skupinske (timsko delo), sodelovanja dvojic (rožici, oblaka) in navsezadnje tudi individualne učne oblike. Prepletla sem naravoslovne vsebine (kroženje vode) s tehniškimi (izdelava kustumov). Pomnjenje pojmov iz vsebinskega sklopa o kroženju vode v naravi bo pri večini učencev zaradi konkretizacije dogajanja najbrž trajnejše kot bi bilo sicer.

PROJECT OF PROTECTING THE FROGS IN PODLJUBELJ / PROJEKT ZAŠČITE ŽAB V PODLJUBELJU (PRIMER POVEZOVANJA ŠOLE IN KRAJANOV ZA ZAŠČITO OGROŽENE ŽIVALSKE VRSTE)

Romana Turk

OŠ Tržič

romana.turk@guest.arnes.si

ABSTRACT

In spring 2006 the students gave notice on how the road through the village Deševno is literally covered with run-over frog corps. With the help of the local community we have acquired all the necessary location information and the students along with the teachers considered all the technical details about setting up a security fence. The first setting up of a fence was performed in March 2008. We ascertain that our project contributed considerably to preservation of our natural heritage, since we managed to save 86 frogs in a single rainy spring night.

Keywords: *frogs, migration, security fence, community*

UVOD

Šola mora biti povezana z življenjem. Odraža naj značilnosti ljudi in kraja, kjer živijo njeni učenci. Zato je prav, da sprejemamo njihove želje, pobude in opažanja. Redko pa se rešitve, ki jih predlagamo v šoli, uresničijo.

Opisan projekt zaščite dvoživk ob bajerju Jezerc v Podljubelju je primer dobre povezave šole, krajanov in širše lokalne skupnosti. Premagali smo finančne, administrativne in tehnične ovire, tako da projekt še živi. Zaščitno ograjo tako postavljamo že tretje leto zapored.

METODA

Tabela 1: Cilji, metode dela

Cilji:	Metode, oblike dela:
Učenke in učence - vzgajati v duhu pozitivnega odnosa do narave, - uriti v tehnikah opazovanja, načrtovanja, - razvijati njihove ročne spretnosti, - učiti jih sodelovalnega učenja, - učiti jih osnovnih bioloških zakonitosti, - razvijati čut za prostovoljno delo.	- terensko delo, - eksperimentalno delo, - praktično delo, - metoda risanja, beleženja podatkov - raziskovalno delo

Cilje smo uresničili na naravoslovnem dnevu, interesnih dejavnostih, na delovnih akcijah v prostem času, na ekodnevu.

REZULTATI

Ugotavljanje pomanjkljivosti v okolju, opozarjanje na okoljske probleme je brez pomena, če ne vodi do konkretnih rešitev. Projekt zaščite dvoživk v Podljubelju je primer povezovanja teoretičnih vsebin s prakso, primer povezovanja šole in lokalne skupnosti. Poleg strokovnega znanja s področij biologije, tehnike, varstva okolja, ki so ga učenci in sodelavci pridobili pri dejavnostih projekta, ima posebno vrednost zaradi preseganja pogostih predsodkov o žabah.

Povezali smo se s strokovnjaki Biotehniške fakultete iz Ljubljane, Centrom za kartografijo favne in flore, člani Lions kluba in županom naše občine.

Vsi sodelujoči smo opazovali, delali, popisovali, reševali, prepričevali in nenazadnje tudi moledovali za to, da lahko zaščitno ograjo postavljamo že več let zapored. Pri tem pa nam pomagajo tudi občina in krajevna skupnost ter lastnik zemljišča.

ZAKLJUČEK

Projekt zaščite žab v Podljubelju je zelo zahteven, saj je potrebno sodelovanje širše skupnosti. Že na začetku smo ga zasnovali tako, da nadaljujemo z delom tudi v naslednjih letih. Učenke, učenci in učitelji smo že »pravi mojstri« za postavljanje ograje, saj jo del vsako pomlad in jesen podremo in potem ponovno namestimo. Teren ob bajerju Jezerc je postal vzorčni primer za zaščito žab pred selitvami čez prometne ceste. Pogosto ga obiskujemo z učenci naše šole. Tam izvajamo naravoslovne, tehniške dneve. Skratka, ugotavljamo, da je postal naša učilnica na prostem, kjer v naravi lahko opazujemo življenjsko pestrost. Za krajane pa je prostor oddiha in sprostitve.

Slika 1: Zaščitna ograja

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ENCOURAGING YOUTH FOR NATURAL SCIENCES AND TECHNICS
/
SPODBUJANJE MLADIH ZA NARAVOSLOVJE IN TEHNIKO

Karmen Vidmar

Gimnazija Jurija Vege Idrija

karmen.vidmar@guest.arnes.si

ABSTRACT

In Idrija there companies that are in the lead in their branches. Their development demands more educated employees of electronics and mechanical engineering. Secondary school GJV Idrija is the only such school in the region and has a crucial role in directing students into deficient jobs. Visits to companies, showing students chances of employment and introducing students to the work in laboratories are activities that were carried out in the project Encouraging youth for natural sciences and technics. During the visits students did one of the obligatory laboratory exercises in physics in laboratories of the companies Kolektor and Hidria.

Keywords: *Laboratory exercises, technical occupations, company, natural sciences and technics*

UVOD

Idrija je bila stoletja rudarsko mesto, ki je tradicijo rudarjenja prenašalo iz roda v rod. Ob zatonu rudnika živega srebra se je v mestu in njegovi okolici začela razvijati strojna- in elektroindustrija, ki je počasi, toda vztrajno začela preraščati okvire dodatnega delodajalca nizkokvalificirane delovne sile. Danes sta Kolektor in Hidria podjetji, ki igrata na svetovnem trgu pomembno vlogo v svojih panogah; podvrženi sta močni konkurenci in vedno novim izzivom. Da lahko ostaneta ključna igralca na tem trgu, pa je pomemben priliv visoko strokovnega kadra, ki ga med drugim zagotavljajo slovenske univerze. Kljub izjemno veliki ponudbi štipendij za področje tehnike in naravoslovja v občini Idrija so le-te zaradi premejhnega zanimanja dijakov ostajale nepodeljene.

Sami začetki projekta »Spodbujanje mladih za naravoslovje in tehniko« segajo v januar leta 2005. Tedaj me je podpredsednik koncerna Kolektor seznanil s kadrovsko problematiko podjetja in načrti zaposlovanja v podjetju. Kot učiteljico fizike na idrijski gimnaziji so me povabili k sodelovanju pri pridobivanju kadrov s področja tehnike in naravoslovja. Ker je fizika eden izmed ključnih predmetov za bodoče študente tehnike, sem videla v tovrstnem povabilu izziv, kako približati fiziko in njeno uporabno vrednost mladim. Laboratorijske vaje so eden izmed načinov, da dijaki spoznajo neposredno delovno okolje razvojnega inženirja. S seznanitvijo dijakov z delovnim okoljem in z možnostjo graditve nadaljnje kariere v tujini bi deficitarni poklici postali dijakom zanimivejši, kar bi posledično pomenilo, da bi se dijaki v večjem številu odločali za tovrstne študije.

METODA

Projekt »Spodbujanje mladih za naravoslovje in tehniko« je kot inovacijski projekt tekel 3 leta v sodelovanju z Zavodom za šolstvo. Prvič smo v projekt vključili generacijo gimnazijcev, ki je v šolskem letu 2005/06 obiskovala 1. letnik. Da bi potrdili pravilnost naše odločitve o vključitvi mladih v projekt, smo vseskozi spremljali in preverjali odziv te generacije na sam potek laboratorijskih vaj. Postopoma smo vsako šolsko leto v projekt vključevali nove generacije gimnazijcev. Tako še danes dijaki vsako šolsko leto opravijo po eno izmed obveznih vaj pri pouku fizike v enem izmed laboratorijev korporacij Hidria in Kolektor. Vse vaje dijaki izvedejo v času, namenjenem laboratorijskim vajam. Vajo v prvem in tretjem letniku dijaki izvedejo v dveh šolskih urah (v ta čas je vštet tudi prihod dijakov na podjetje in kratek ogled proizvodnje), kar je mogoče zaradi relativne bližine podjetja Kolektor. V drugem letniku dijaki opravijo laboratorijsko vajo iz fizike na Inštitutu Klima v Godoviču, ki je nekaj kilometrov oddaljen iz Idrije. Izvedbo vaje združimo z ogledom inštituta in proizvodnje IMP Klima Godovič, ki je del korporacije Hidria, zato v Godovič z avtobusom odpeljemo dva razreda hkrati. Zaradi oddaljenosti laboratorija izvedba vaje presega dve šolski uri.

Izbira vaj temelji na učnih vsebinah v posameznih letnikih. Za samo izbiro teme je bil potreben predhodni ogled laboratorijev in prilagajanje meritev in merilnih instrumentov dijakom. Tako v prvem letniku opravijo vajo s področja sil pri kroženju (Podiranje kolektorja), v drugem letniku s področja toplotnega sevanja (Analiza portreta z infrardečo kamero), v tretjem letniku s področja elektrike (izdelava tiskanega vezja, ki mora zadostiti danim pogojem – uporaba Ohmovega zakona). Pred vsakim opravljanjem vaj dijaki dobijo navodila, s pomočjo katerih izvedejo meritev in izdelajo končno poročilo.

REZULTATI

Projekt smo evalvirali le pri prvi generaciji. Svetovalna delavka je anketirala dijake o študijskem interesu za naravoslovje in tehniko ob vpisu v prvi letnik. Hkrati so na vprašalnik odgovarjali dijaki, ki so bili ob vpisu prve generacije dijakov vključeni v projekt v tretjem letniku. Odgovori niso pokazali bistvenih razlik v interesu za študij naravoslovja med tretješolci in prvošolci, kljub temu da so bili tretješolci v času izvedbe ankete že vključeni v informiranje o prednostih zaposlovanja in študija v tehničnih poklicih. Leta 2008 je generacija dijakov, ki so bili prvi vključeni v projekt, zaključevala tretji letnik. V mesecu maju, ko so vsi dijaki opravili v vsakem letniku vsaj po eno vajo v podjetjih, so ponovno odgovarjali na anketni vprašalnik o študijskem interesu. Izpolnili so tudi evalvacijski vprašalnik, s katerim smo preverili vpliv vaj na njihovo morebitno odločitev za naravoslovje in tehniko. Iz primerjave odgovorov na vprašalnike, ki so jih dijaki izpolnjevali v prvem in v tretjem letniku, se je pokazalo, da je interes za naravoslovje in tehniko pri dijakih prve generacije narasel.

Iz evalvacijskih vprašalnikov smo razbrali, da je večini dijakov (60,3% ali 44 vseh anketiranih) tovrstno opravljanje laboratorijskih vaj pomenilo dragoceno izkušnjo. 75,3% ali 55 vseh anketiranih dijakov je odgovorilo, da je tovrstna izkušnja vplivala na njihov interes za tehniko in naravoslovje, pri precejšnjem deležu (50,7% ali 37 vseh anketiranih) pa je interes za naravoslovne in tehnične poklice narasel, pri čemer 86,5% ali 32 vseh anketiranih navaja, da je k temu prispevala tudi izvedba vaj v podjetjih, iz česar lahko sklepamo, da je od 73 anketiranih dijakov vsaj 37 (50,7%) takšnih, ki kažejo interes za tehniko in naravoslovje.

ZAKLJUČEK

Primerjava rezultatov analiz odgovorov na vprašalnike je pokazala, da tovrstno izvajanje vaj v neposrednem okolju podjetij pripomore k lažji odločitvi dijakov za tehnične poklice. Prav tako primerjava med analizo interesov, izvedeno med tretješolci leta 2006 in tretješolci, ki so bili vključeni v projekt leta 2008, kaže porast interesa za tehniko in naravoslovje. Leta 2006 je bilo takšnih 25,3%, leta 2008 pa 50,7%.

Izvajanje laboratorijskih vaj v laboratorijih podjetij je novost, ki pomeni dijakom neprecenljivo izkušnjo. Je nov model opravljanja obveznih vaj na drugačen način in v avtentičnem okolju podjetij. Dijaki se soočajo z dejavnostmi podjetja in spoznavajo uporabnost naravoslovnih ved, hkrati pa spoznajo delo strokovnjakov z deficitarnim poklicem.

Model izvajanja vaj je uporaben v vseh šolah z vzgojno-izobraževalnimi programi s predpisanimi obveznimi laboratorijskimi vajami.

Gimnazija Jurija Vege Idrija vsa leta, od prvih izvedb vaj pa do danes, ohranja tovrsten način sodelovanja z industrijo. Še več, sodelovanje krepi in ga nadgrajuje z dodatnimi aktivnostmi za dijake. Nadarjeni dijaki imajo možnost opravljati počitniško delo v razvojnih laboratorijih in s pomočjo mentorjev iz podjetij izdelati raziskovalne in seminarske naloge.

Dobro sodelovanje med šolo in domačimi podjetji je prineslo večjo vključenost šole v lokalno okolje, hkrati pa se je povečal tudi interes industrije za čim boljše pogoje dela dijakov in učiteljev na šoli .

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PROJECT WORK AS A GOOD STRATEGY FOR WORKING WITH GIFTED SCHOLARS IN ENGINEERING AND TECHNOLOGY
/
PROJEKTNA NALOGA KOT DOBRA STRATEGIJA ZA DELO Z NADARJENIMI UČENCI PRI TEHNIKI IN TEHNOLOGIJI

Janez Virtič

OŠ Sava Kladnika Sevnica

janez.virtic@guest.arnes.si

ABSTRACT

Article discusses project work as an integrated strategy with constructivistical view of learning, developing scholars' creativity and other personal potentials. Project work is embedded in the educational work of layout problem, seeking solutions by sketching and modeling, prototyping, technological documentation, organization of production and economics of the product. The present strategy not only stimulates cognitive functioning, but also includes personal aspect of the scholar and encourages motivation and respectful teacher-scholar relation. The process allows scholars to gain additional knowledge and skills in a creative way according to their capabilities. Furthermore, it enables deepening, repetition and use of knowledge in the areas of technology, industrial design, work organization, economics and sustainable living.

Keywords: *Project work, gifted, creativity, capability, sustainable development.*

UVOD

Projektna naloga je tista strategija vzgojno-izobraževalnega dela, kjer gre za razvoj divergentnega mišljenja in ustvarjalnih sposobnosti. S konstruktivističnim pogledom pa je izobraževalna teorija, ki poudarja, da učenje poteka še posebej učinkovito takrat, ko učenci doživljajo izkustvo in tvorijo smiselni produkt. Znanje usvajajo tako, da so v obliki vloge dejavno vključeni v učni proces in na ta način gradijo oziroma konstruirajo znanja na osnovi izkušnje. Najpomembnejše je vodilo, da otrok konstruira svoje znanje sam, z lastnimi izkušnjami, pri čemer igra pomembno vlogo okolje (šolsko in življenjsko) in moč doživljanja v procesu pridobivanja znanja (Krapše, 1999). “Nadarjenost je sestavljena iz interakcije med tremi osnovnimi grozdi človeških potez: nadpovprečne splošne intelektualne sposobnosti, visoke stopnje zavzetosti za izpolnjevanje nalog (motivacija) in visoke stopnje ustvarjalnosti” (Ferbežer, 2002: 35). Postavlja se vprašanje, kako organizirati učno-vzgojni proces, da pride do interakcije vseh potez. Le tenkočutnost vzgojno-izobraževalnega sistema in procesov do mladega človeka bo prinesla pričakovane vzgojno-izobraževalne rezultate.

METODA

Simbioza in senzibilnost projektne naloge v učnem procesu s svojimi dejavnostmi in taksonomsko fleksibilnostjo na vseh zahtevnostnih ravneh, omogoča vsem udeležencem enakopravno udeležbo in po zmožnostih prilagojeno dejavnost, ter učno-vzgojni napredek posameznika.

Projektna naloga

Projektna naloga kot učna strategija ima razvojne stopnje razčlenjene po korakih in se med avtorji nekoliko razlikujejo po razporeditvi, interpretaciji in poimenovanju korakov.

Moja dolgoletna izkušnja potrjuje, da je zelo primerna naslednja razčlenitev:

- **Načrtovanje projektne naloge, skiciranje in izbor idejne rešitve;** Iskanje učenčevih močnih interesnih področij, omejitev problema, postavitev kriterijev za razvijanje in skiciranje ideje, skiciranje in modeliranje ideje (lahko računalniško), Izbor najboljše rešitve po kriterijih.
- **Izdelava prototipa;** Izbor gradiv (labolatorijsko preizkušanje gradiv), izbor orodij in strojev, izdelava prototipa, preizkušanje prototipa, korekture in dopolnitve prototipa.
- **Izdelava tehnične in tehnološke dokumentacije;** Dopolnitev znanj tehničnega risanja, delavniška, montažna risba s kosovnico, tehnološki list.
- **Organizacija in stabilizacija delovnega mesta, ekologija;** Razdelitev delovnih mest po interesih, Racionalizacija delovnih postopkov (izdelava šablon), ergonomsko in varno delovno mesto, skrb za okolje (odpadki, energija).
- **Izvedba proizvodnje;** Proizvodnja sestavnih delov na zalogo, montaža sestavnih delov v celoto.
- **Ekskurzija v proizvodni obrat;** Načrtovanje ogleda v obrat proizvodnje, ogled in reševanje delovnih listov, analiza ogleda.

Analiza in ekonomika projekta, vrednotenje; Analiza vlog posameznikov v procesu projektne naloge, pomen skrbno načrtovane proizvodnje, vplivi na ceno izdelka, izračun cene izdelka (program kalkulacije), poklicne potrebe

ANALIZA IN REZULTATI

Konstruktivistično naravnano usmerjanje učenja omogoča manjšo in počasnejšo »kopnenje« znanja, kar je moč sklepati, če nekaj skonstruiraš sam oziroma se do nečesa sam dokoplješ na svoj način, ima le-to daljšo in močnejšo obstojnost. Hkrati pa je to močan dejavnik, ki razvija notranjo motivacijo za nadaljnje učenje in ne nazadnje prispeva tudi k pozitivnemu čustvenemu vrednotenju (sebe, krepitvi samopodobe, znanja in tudi učitelja kot usmerjevalca.

ZAKLJUČEK

Ustvarimo pogoje, da bo upoštevano spoznanje konstruktivistov, ki pravi, da znanja v gotovi obliki ne moreš drugemu “dati” niti od nekoga “sprejeti”, ampak ga mora vsakdo z lastno miselno aktivnostjo ponovno zgraditi in pri tem ima projektna naloga odločilno vlogo in pomen. To pa naj pomeni izziv in možnost za odkrivanje in razvijanje nadarjenih otrok (Amand Papotnik, 2003). Družba brez praktične ustvarjalnosti in iskanja novih rešitev v proizvodnji, ekonomiki, trgu blaga in dela, bo težko preživela ali se izvila iz gospodarske krize. Naložba znanj v mladega človeka je dolgoročna razvojna strategija družbenega razvoja.

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Soavtorstvo učbeniških kompletov: Tehnika in tehnologija 6.r, 7.r, 8.r, Obdelava gradiv umetne snovi, Obdelava gradiv kovine, Elektrotehnika, izdaja pri založbi IZOTECH.

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HOW CAN WE EVOKE INTEREST OF STUDENTS IN SCIENCE AND THEIR BETTER ACADEMIC ACHIEVEMENTS?
/
KAKO SPODBUJATI INTERES MLADIH ZA NARAVOSLOVJE IN ZAGOTAVLJATI DOBRE ŠTUDIJSKE DOSEŽKE?

Margareta Vrtačnik

Univerza v Ljubljani,
Naravoslovnotehniška fakulteta

metka.vrtacnik@guest.arnes.si

Vesna Ferk Savec

Univerza v Ljubljani,
Naravoslovnotehniška fakulteta

vesna.ferk@ntf.uni-lj.si

Saša A. Glažar

Univerza v Ljubljani, Pedagoška fakulteta

sasa.glazar@guest.arnes.si

ABSTRACT

Previous research has proven that academic achievements are positively correlated with autonomous motivation. Students from 10 Slovenian *grammar schools* were involved in empirical study, in which a cluster analysis revealed two motivational profiles: a low quantity motivation group (low controlled and autonomous motivation) and a good quality motivation group (high autonomous and low or average controlled motivation). Statistically significant differences between the two identified motivational profiles were found for students' general as well as chemistry performance in three grades of schooling. Furthermore, a good quality motivation group is also more in favour of autonomy-supportive teaching methods used in chemistry classes.

Keywords: *students' motivational profiles, academic achievements*

UVOD

Raziskave na področju teorije učenja, ki so v zadnjih desetletjih omogočile vpogled v proces učenja, so v šolsko prakso uvedle vrsto novih strategij učenja in poučevanja (Dreyfus, Jungwirth, in Eliovitch, 1990; Niaz, 1995; Posner, Strike, Hewson, in Gertzog, 1982; Dykstra, Boyle, in Monarch, 1992). Tradicionalen način poučevanja, ki temelji predvsem na predavanjih, pri katerih so učenci in dijaki zgolj pasivni prejemniki informacij in podatkov, so začele nadomeščati bolj aktivne oblike poučevanja in učenja, ki jih v zadnjem času, tudi pri nas, vgrajujemo v učne načrte predmetov kot didaktična priporočila in uvajamo v v šolsko prakso. Razumevanje procesa učenja je omogočilo razvoj modelov učenja in poučevanja, pri katerih učenci in dijaki samostojno, preko različnih aktivnosti, razvijajo svoje lastne teoretične okvire stroke in si bolj ali manj samostojno gradijo bazo znanja. Vloga učitelja v tem procesu je predvsem usmerjevalna. Učitelj dopolnjuje nepopolne ali celo napačne predstave in usmerja ter spodbuja razmišljanje. Na področju naravoslovnega izobraževanja se je uveljavil zlasti izkustveni pristop, ki temelji na samostojnem odkrivanju novega znanja na osnovi načrtovanja in izvajanja eksperimentov, ali iskanju podatkov in informacij v ustreznih informacijskih virih, njihovi analizi, sintezi ter povezovanju s teorijo. Vendar so rezultati raziskav o učinkvitosti novih učnih strategij pri naravoslovnih predmetih, v primerjavi s tradicionalnimi, često nasprotujoči. Tako nekatere raziskave dokazujejo, da so novi pristopi brez pravega učinka na kvaliteto znanja (Pine in sodelavci, 2006), druge (McCarthy, 2005; O'Neill, 2004) pa kažejo na večjo učinkovitost aktivnih pristopov učenja in poučevanja v primerjavi s tradicionalnimi pristopi. Novejše študije učne motivacije odkrivajo vzroke za takšno stanje, saj so učni oz. študijski uspehi vedno v pozitivni korelaciji z motivacijskimi profili učeče se populacije in posredno, z motivacijskim profilom učitelja (Fortier, Vallerand, in Guay, 1995; Grolnik, Ryan, in Deci, 1991; Guay, in Vallerand, 1997; Ratelle, Guay, Vallerand, Larose, in Senécal, 2007). Motivacija za učenje je visoko kvalitetna, če temelji na avtonomni motivaciji, ki jo nadzirajo intrinzični, identificirani in integrirani motivacijski regulatorji oz. je nizke kvalitete, če temelji na kontrolirani motivaciji, ki jo nadzirajo zunanji in introjecirani regulatorji (Guay, Ratelle, in Chanal, 2008). Raziskave na področju motivacije so tudi dokazale, da so učenci in dijaki znatno bolj avtonomno motivirani, če učitelj uporablja avtonomen stil poučevanja, ki zagotavlja sproščeno, vendar delovno učno okolje (Chirkov, in Ryan, 2001; Vansteenkiste, Simons, Lens, Sheldon, in Deci, 2004). V pričujoči raziskavi smo preučevali motivacijske profile naših gimnazijcev in povezanost motivacijskega profila s splošnim uspehom in uspehom pri kemiji ter odnosom do učnih pristopov pri pouku kemije.

METODA

Za ugotavljanje motivacijskih profilov smo modificirali poseben motivacijski vprašalnik (Black in Deci, 2000; Juriševič, Razdevšek Pučko, Devetak, in Glažar, 2008) z 31 trditvami, do katerih so morali testiranci izraziti raven strinjanja z uporabo Likertove lestvice od 1 do 5 (1 = zame ta trditev ne velja; 5 = zame ta trditev povsem velja). Trditve so ustrezale posameznim motivacijskim regulatorjem za prepoznavanje avtonomne in kontrolirane motivacije ter samopodobe. Pri opredeljavanju motivacijskih profilov je bila uporabljena klasifikacija, ki so jo predlagali Vansteenkiste s sodelavci (2009). V raziskavi je sodelovalo 361 gimnazijcev in gimnazijk iz 10 gimnazij. Povprečna starost testirancev je bila 16,4 leta. Testiranje smo izvedli v maju in juniju leta 2009. Za klasifikacijo smo uporabili metodo K-tega najbližjega soseda, za ugotovaljanje statistične pomembnosti razlik med skupinama pa t-test.

REZULTATI

Klasifikacija dijakov glede na vrednosti kontrolirane in avtonomne motivacije (notranje in regulirane) ter samopodobe z metodo K-tega najbližjega soseda pokaže, da lahko dijake glede na izbrane klasifikacijske kriterije razdelimo v dva klastra oz. skupini. Za dijake, ki pripadajo I. skupini, je značilna podpovprečna avtonomna (notranja 2 in regulirana 2) motivacija in podpovprečna kontrolirana motivacija (2), Tabela 1. Ti dijaki se uvrščajo v motivacijsko skupino *nizke kvantitete*. Dijaki II. skupine sodijo v skupino *dobre kvalitete* (povprečna kontrolirana motivacija (3) in nadpovprečna avtonomna motivacija (notranja 4 in regulirana 4)). Vpliv motivacijskega profila na splošni učni uspeh in na uspeh pri kemiji je prikazan v Tabeli 2 in statistična pomembnost razlik v Tabeli 3.

Tabela 1: Rezultat klasifikacije

Začetni centri klastrov			Končni centri klastrov			Število primerov klastrih		
	Klaster			Klaster		Klaster	1	171
	I	II	Notranja motivacija	I	II		2	189
Notranja motivacija	1	5	Samopodoba	2	4	Veljavni		360
Samopodoba	1	5	Kontrolirana motivacija	2	3	Manjkajoči		1
Kontrolirana motivacija	2	3	Regulirana motivacija	2	3			
Regulirana motivacija	1	5	Notranja motivacija	2	4			

Tabela 2: Odvisnost predhodnega šolskega uspeha od motivacijskega profila

Uspeh	*Skupina*	N	Srednja vrednost	Std. deviacija	Std. napaka
Splošni uspeh 1.razred	I	166	3.49	.807	.063
	II	182	4.03	.814	.060
Splošni uspeh 2. razred	I	114	3.33	.816	.076
	II	117	4.07	.817	.076
Splošni uspeh 3. razred	I	36	3.64	.867	.144
	II	40	4.50	.641	.101
Kemija 1. razred	I	166	3.19	.959	.074
	II	182	4.01	.934	.069
Kemija 2. razred	I	114	2.88	.923	.086
	II	117	3.96	1.003	.093
Kemija 3. razred	I	37	3.27	.871	.143
	II	40	4.45	.677	.107

Tabela 3: T-test enakosti srednjih vrednosti

						95 % interval zaupanja	
	t	df	Sig. (2-tailed)	Srednja vrednost razlik	Std. napaka razlike	Nižja	Višja
Kem 1. r.	-8.057	346	.000	-.818	.102	-1.018	-.618
Kem 2. r.	-8.508	229	.000	-1.080	.127	-1.330	-.830
Kem 3. r.	-6.663	75	.000	-1.180	.177	-1.532	-.827
Sp. us. 1. r.	-6.196	343	.000	-.539	.087	-.710	-.368
Sp.us. 2. r.	-6.838	229	.000	-.735	.107	-.947	-.523
Sp. us. 3. r.	-4.957	74	.000	-.861	.174	-1.207	-.515

Na ravni signifikantnosti 0,01 so bile s t-testom dokazane statistično pomembne razlike med splošnim uspehom in uspehom pri kemiji med pripadniki motivacijske skupine *nizke kvantitete* (skupina I.) in motivacijske skupine *dobre kvalitete* (skupina II.) Testiranci, ki so uvrščeni v motivacijsko skupino *dobre kvalitete* (II. skupina) imajo statistično pomembno bojši splošni učni uspeh in oceno iz kemije v vseh treh razredih gimnazije. Motivacijski profil dijakov se je odrazil tudi v njihovem odnosu do različnih strategij poučevanja kemije. Tako so za motivacijsko skupino dobre kvalitete povprečne ocene, ki so jih dijaki dali posameznim učnim pristopom, statistično pomembno višje na ravni signifikantnosti 0,01 za odnos do predavanj in izkustvenega pristopa in na ravni signifikantnosti 0,05 tudi za samostojno delo z učbenikom. Dijaki, ki se uvrščajo v motivacijsko skupino, za katero je značilna nadpovprečno visoka avtonomna motivacija, kažejo bolj pozitivni odnos do avtonomnega stila poučevanja, hkrati pa tudi bolje cenijo dobro učiteljevo razlago v primerjavi z dijaki, ki pripadajo motivacijski skupni nizke kvantitete.

Rezultati o priljubljenih in nepriljubljenih kemijskih vsebinah in vzrokhih za interes so odkrili, da sta glavna vzroka za nepriljubljenost nekateih kemijskih vsebin poleg splošne odsotnosti interesa, nerazumljiva učiteljeva razlaga in nepovezanost izbranih vsebin z življenjem. Kar preseneča je dejstvo, da so dijaki med z življenjem nepovezane vsebine uvrstili vrsto vsebin iz organske kemije (npr. ogljikove hidrate, proteine, nafto), elektrokemijo, vključno z galvanskimi členi in elektrolizo ter entalpijo. Lahko trdimo, da se v odklonilnem odnosu dijakov odraža učiteljev pristop. Po ugotovitvah Black-a in Deci-a (2000) ter Reeve-a (2009) je učiteljeva odgovornost, da poveže vsebine z izkustvi učencev oz. dijakov in da izbere takšno učno strategijo, ki bo zagotavljala dobre učne rezultate. Nerazumljiva učiteljeva razlaga, brez uporabe sodobnih vizualizacijsih sredstev (eksperiment, IKT) je že sama po sebi dovolj tehten razlog, ki odvrne dijake od določene vsebine in znižuje že tako nizko avtonomno motivacijo

ZAKLJUČEK

V raziskavi sta bila identificirana dva motivacijska profila dijakov; motivacijski profil *nizke kvantitete* in *dobre kvalitete.* Raziskava je potrdila rezultate predhodnih, da imajo najboljše učne uspehe tisti dijaki, ki se uvrščajo v motivacijsko skupino *dobre kvalitete*, tem dijakom tudi najbolj ustreza avtonomni stil poučevanja, ki se je odrazil na njihovem bolj pozitivnem odnosu do avtonomnega stila poučevanja.

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FEELING GREAT IN YOUR OWN SKIN
/
DOBRO POČUTJE V LASTNI KOŽI

Petra Vrtačnik Žveplan

OŠ Tončke Čeč Trbovlje

petra@softdata.si

ABSTRACT

The title of the topic is »Feeling great in your own skin«. Students make different cosmetics such as: relaxing massage oil, scented bath salt, cucumber tonic, hand cream, lip balsam, calendula cream, liquid soap, herbal soap, scented liquids, air freshener. Before starting all the students get detailed instructions for work and a work sheet. The students learn to use various laboratory techniques, they learn to measure, weigh, how to use the burner, they also familiarise themselves with the healing properties of plants and most importantly, how to apply these skills in everyday life.

Keywords: *Cosmetics workshop.*

UVOD

Glede na to, da je velik poudarek pri naravoslovju na diferenciaciji pouka in na drugačnih metodah dela, sem se odločila, da kot prispevek pošljem primer dobre prakse, ki ga izvajam že četrto leto, seveda z vsakoletnimi izboljšavami in dopolnitvami. Zadeva je uporabna za izbirni predmet, za delo z nadarjenimi učenci, za naravoslovni dan, za dodatni pouk, za naravoslovni krožek, za prednovoletne delavnice, konec koncev pa tudi za popestritev rednega pouka. Različni poskusi so namenjeni učencem v tretji triadi, nekateri poskusi pa so primerni tudi za učence druge triade, ali pa za učence prilagojenega izobraževalnega programa z nižjim izobrazbenim standardom.

METODA

Metoda dela je eksperiment. Moje mnenje je, da učenci pridejo do kakovostnejšega in trajnega znanja le s pomočjo raziskovanja, reševanja problemov in izvajanja poskusov. Učenci delajo v skupinah, na koncu vsak učenec preizkusi svoj kozmetični pripravek. Naslov kozmetične delavnice je : »Dobro počutje v lastni koži«. Učenci izdelujejo različne kozmetične pripravke, kot so:

- sproščujoče masažno olje,
- dišeča kopalna sol,
- kumarični tonik,
- krema za roke,
- balzam za ustnice,
- ognjičeva krema,

- tekoče milo,
- zeliščno milo,
- dišavna tekočina,
- osvežilec zraka.

REZULTATI

Glede na to, da so rezultati večletnega dela pokazali izredne uspehe, sem se odločila, da to predstavim tudi drugim kolegom. Najpomembnejše je dejstvo, da učenci spoznajo uporabnost kemije v vsakdanjem življenju.

Poskusi so preprosti, povsod je na prvem mestu varnost in zaščita. Pred začetkom dobijo učenci natančna navodila za delo in delovni list. Skoraj vsi poskusi so namenjeni za eno šolsko uro, razen izdelave kumaričnega tonika. Učenci se naučijo uporabljati različne laboratorijske tehnike, naučijo se natančnega merjenja in tehtanja, urijo se v uporabi gorilnika, spoznajo različno uporabnost zdravilnih rastlin, kar pa je najpomembnejše, znajo uporabiti znanje naravoslovja v vsakdanjem življenju.

Pri delu vedno vsi uživamo, učenci so navdušeni in zadovoljni. S preprostimi poskusi nam uspe izdelati različne kozmetične pripravke, ki nam izboljšajo počutje ali polepšajo dan.

ZAKLJUČEK

V prilogi so vse recepture oziroma postopki izdelave posameznih kozmetičnih pripravkov, učno delovni listi in seveda navodila za delo. Včasih je problem embalaža, sami največkrat uporabimo embalaže oziroma lončke kupljenih, že porabljenih krem, včasih pa lončke nabavimo v lekarni ali v steklarniški trgovini. Pri ustvarjanju vam želim veliko uspeha.

THE CANYON OF KOKRA: FROM IDEA TO PRODUCT / KANJON KOKRE: OD IDEJE DO IZDELKA

Bojana Zavolovšek

ESIC Kranj

bojana.zavolovsek@guest.arnes.si

ABSTRACT

In the programme civil engineering technician, a lot of time is spent getting to know the local landscape. As there is in the nearby vicinity of the school virtually an outdoor classroom – the canyon of the Kokra river. As students also learn to produce a model at professional civil engineering subjects, we decided to produce a model of the Kokra canyon, We made a plan how to produce a model. And it is exactly the project work the very thing where students can consolidate theoretical knowledge from multiple subjects, due to which student's knowledge becomes more durable and more useful.

Keywords: C*reative work, Kokra canyon, local landscape.*

UVOD

Cilj projekta je bila izdelava makete kanjona reke Kokre. Projekt sem izvedla z dijaki Srednje gradbene šole, smer gradbeni tehnik, pri urah geografije, delno v prisotnosti učiteljice umetnosti pri urah umetnosti in pri v prisotnosti učitelja pri predmetu osnove projektiranja.

Dijaki se pri različnih strokovnih predmetih učijo praktične uporabe pridobljenega znanja. Že med samim izobraževanjem morajo v okviru delovne prakse praktično predstaviti različne projekte in naloge. Zato sem se odločila, da tudi v okviru predmeta geografija predstavim nekaj praktičnega dela, katerega ideje bodo lahko uporabili pri predstavitvah.

Zakaj sem izbrala prav kanjon reke Kokre? Pri pouku geografije veliko časa namenimo spoznavanju domače pokrajine. Ker imamo v neposredni bližini šole tako rekoč učilnico na prostem – kanjon reke Kokre, sem se odločila tej pokrajini nameniti nekoliko več časa in jo temeljito raziskati, opisati in predstaviti tudi nekoliko drugače. Želela sem, da teoretično znanje postane trajnejše in bolj uporabno.

Cilji našega projekta so bili naslednji:

- razvijamo sposobnost dijakov za uporabo preprostih raziskovalnih metod, s katerimi pridobivajo in posredujejo znanje o pokrajini
- razvijamo zanimanje dijakov za domačo pokrajino
- pridobivajo in razvijajo sposobnost za opazovanje naravnih in družbenih pojavov in procesov v pokrajini
- naučijo se izdelati nekatere vrste zemljevidov in se znajo orientirati na različnih zemljevidih in v naravi

- probleme preučijo sami ali v skupini, pri čemer upoštevajo načela individualiziranega ali timskega dela, motivacije in kreativnosti
- aktivno sodelovanje dijakov v vseh fazah didaktičnega projekta
- razvijajo ročne spretnosti
- razvijamo občutek estetike
- zadovoljstvo in sprostitev med delom
- navadijo se pripraviti in pospraviti delovni prostor

METODA

Projekt smo začeli s pogovorom o domači pokrajini. Obnovili smo znanje o tipih površja, delovanju reke in rečnih dolinah. Ogledali smo si kanjon reke Kokre in ga fotografirali. Dijaki so dobili v razmislek, kako bi s pomočjo znanja strokovnih predmetov izdelali maketo kanjona. Predstavili so veliko zanimivih idej, večina pa se jih je nanašala na uporabo gline in stiropora. Tako je postalo glavno vodilo našega projekta: Kako s pomočjo znanja geografije, osnov projektiranja in umetnosti izdelati maketo kanjona reke Kokre.

Po teoretičnem delu je sledil praktični del – izdelava makete.

Z dijaki in profesorjema predmetov osnove stavbarstva in umetnosti smo se dogovorili o nabavi ustreznih materialov. Dijaki so s pomočjo interneta poiskali najugodnejšo ponudbo materiala v trgovini.

Pri uri predmeta osnove projektiranja naj bi dijaki s pomočjo računalnika iz topografskega načrta v merilu izrisali plastnice izbranega dela kanjona in jih preslikali na papir. Pri urah geografije bi iz stiropora izrezali plastnice ter jih »sestavili« v pravo obliko izbranega dela kanjona. Pri urah umetnosti pa izdelali še drevesa in hiše ter jih umestili v maketo.

Maketo bi razstavili na šoli, predstavili bi jo tudi staršem in bodočim dijakom na informativnem dnevu.

REZULTATI

Skupaj z dijaki smo izdelali MAKRO in MIKRO PLAN realizacije zastavljenih ciljev.

➢ MAKRO PLAN:

- KAJ VEMO?
- maketo bomo izdelali sami
- maketo bomo razstavili v vitrini na šoli
- KAJ SE ŽELIMO NAUČITI?
- kako izdelali maketo
- spoznati uporabnost stiroporja, gline ter drugih materialov in orodij
- slediti fazam ustvarjanja
- znati posredovati izkušnje in znanje
- KAJ BOMO NAREDILI?
- izdelali bomo maketo kanjona Kokre v merilu 1:200

- izdelek bomo razstavili
- naše delo bomo dokumentirali s fotografijami

Nato smo natančneje določili, KAJ bomo delali, KAKO in KDAJ bo potekalo delo pri posameznih predmetih in KAKŠNE zadolžitve bodo imeli dijaki.

➢ MIKRO PLAN:

- GEOGRAFIJA:

- uvodna motivacija: domača pokrajina, kanjon Kokre, rečna erozija, zemljevidi in njihova izdelava, ogled in fotografiranje terena, določitev obsega in merila predstavitve kanjona,
- planiranje dela: katere materiale in orodja bomo potrebovali, kje jih bomo najceneje kupili
- delo v učilnici: izrezovanje plastnic iz papirja in izrezovanje plastnic iz stiroporja
- sestavljanje plastnic, lepljenje
- izrezovanje in lepljenje reke Kokre
- postavljanje dreves, hiš, cest na maketo
- izdelava mostov

- OSNOVE STAVBARSTVA:

- izdelava plastnic s pomočjo računalniškega programa, vsak dijak izriše svojo plastnico
- tiskanje plastnic na papir
- načrt za izdelavo hiš, cest, reke, mostov
- idejna zasnova makete

- LIKOVNA UMETNOST:

- izdelava dreves iz gline, barvanje dreves
- izdelava hiš iz stiroporja, lepljenje streh.

Po teoretičnem delu je sledil praktični del – izvedba makete.

Dijaki so k pouku prinesli ustrezen material in orodja, nekaj materiala smo dobili v šoli.

Že prej smo se dogovorili, da bo večina dijakov delala maketo iz stiroporja pri urah geografije. V ta namen smo dobili tudi poseben prostor, da nam ni bilo potrebno prenašati materiala. Maketo so izdelovali v skupinah, vsak dijak je dobil svojo zadolžitev: eni so izrezovali plastnice, drugi so iz stiroporja izrezovali plastnice, tretji so jih lepili na podlago (iveral 1m x 2m).

Pri uri umetnosti so iz gline v merilu izdelali drevesa in jih pobarvali. V merilu in po načrtu so izrezali hiše, strehe pa sestavili iz smirkovega papirja v barvah strešnikov

Slika 1: Maketa kanjona Kokre

ZAKLJUČEK

Vaja je zanimiva, saj jo izdelamo v zelo kratkem času na dokaj enostaven način. Materiali za delo so dostopni in poceni, navodila za delo preprosta in razumljiva. Za dijakovo izdelavo je zelo enostavna. Največja pazljivost je potrebna pri izrezovanju plastnic in njihovemu sestavljanju.

Z izdelavo profila kanjona Kokre so bili dijaki na nevsiljiv način primorani uporabiti znanja več predmetov in jih prikazati kot konkretni izdelek. Nad projektnim učnim delom so bili navdušeni, saj so bili vključeni v vse faze, v katerih so lahko ustvarjali, tudi po lastnih zamislih. Na končni izdelek so zelo ponosni, saj danes stoji v avli šole.

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PEER INSTRUCTION IN INTRODUCTORY PHYSICS COURSE IN SLOVENIAN SECUNDARY SCHOOL / KOLEGIALNO UČENJE PRI UVODNIH POGLAVJIH FIZIKE V GIMNAZIJI

Marko Žigart

Srednja šola Slovenska Bistrica

marko.zigart@guest.arnes.si

ABSTRACT

The purpose of this article is to present the method of teaching called Peer Instruction on Linear Kinematics used with first-year students in Slovenian secundary school. The traditionally taught control group was used to measure effectiveness of the tested method. We compare performances on conceptual and on standard problems.

Keywords: *Physics Education, Peer Instruction, Elementary Kinematics.*

UVOD

Predstaviti želimo aktivno obliko pouka v 1. letniku gimnazije na primeru premega gibanja. Preverjali smo metodo kolegialnega učenja (*Peer Instruction*), ki jo je v devetdesetih letih prejšnjega stoletja pričel razvijati Eric Mazur s Harvarda. V kasnejših primerih uporabe na različnih ustanovah se je izkazala kot zelo učinkovita aktivna metoda učenja tako v manjših kot večjih heterogenih skupinah.

Kolegialno učenje poteka po točno določenih korakih. Po uvodni predstavitvi snovi sledi učenje ob uporabi kratkih konceptualnih vprašanj izbirnega tipa, ki so pripravljena tako, da razkrivajo in odpravljajo zmotna mišljenja dijakov in dijakinj o pojavih in naravnih zakonitostih ter jih vzpodbujajo k aktivnemu učenju. Vlogo vprašanja lahko nadomesti interaktivni demonstracijski poskus, pri katerem dijaki in dijakinje vnaprej napovejo njegov izid. Vprašanju ali poskusu sledi krajši čas za razmislek. Nato dijaki in dijakinje glasujejo za pravilni odgovor. Po odgovoru v parih ali manjših skupinah razpravljajo o vprašanju in izmenjajo argumente za svoje odločitve. Proces razprave med vrstniki je osrednji del metode kolegialnega učenja, ker zahteva aktivno debato, ki lahko potrdi ali ovrže prvotno sklepanje. Sledi ponovno odgovarjanje na vprašanje, ki praviloma izboljša statistiko pravilnih odgovorov. Šele po drugem glasovanju se poda in pojasni rešitev. Tehnike glasovanja so lahko različne: od dvigovanja tablic do uporabe elektronskih volilnih sistemov, vendar raziskave kažejo, da izbira tehnike ne vpliva neposredno na učinkovitost metode.

Ker je bila metoda prvenstveno razvita in preizkušena v univerzitetnem okolju, na dodiplomskem študiju, nas je zanimalo, kako je z njeno prenosljivostjo v srednjo šolo. Ugotavljali smo tudi, kako učinkuje na pouk prenos iz drugega kulturnega okolja v slovenski prostor.

Prispevek je del magistrske naloge, ki nastaja pod mentorstvom izr. prof. dr. Aleksandra Zidanška.

METODA

V raziskavo smo vključili po sposobnostih in predznanju primerljiva prva letnika, tako da je bil eden izmed njiju kontrolni razred s tradicionalnim poukom. Pred izvedbo raziskave so dijaki in dijakinje reševali diagnostični predtest, s katerim smo ugotavljali njihove sposobnosti konceptualnega razmišljanja in njihovo predznanje. Po končanem obdobju testiranja 7 šolskih ur smo diagnostični test ponovili in rezultate primerjali s predtestom. Ob vseh pozitivnih učinkih metode smo želeli še pokazati, da ima metoda primerljiv pozitiven učinek na dijake in dijakinje z različnimi sposobnostmi in različnim predznanjem.

REZULTATI

V rezultate testiranja smo vključili tiste dijake in dijakinje, ki so reševali pred- in končnitest. V testiranem razredu (TR) je bilo 31, v kontrolnem (KR) pa 26 dijakov in dijakinj. Predtest je pokazal rahlo razliko v predznanju in sposobnostih obeh skupin: TR je dosegel 31,5 %, KR pa 36,5 % rezultat. Pri končnem testu, ki se je v nekaterih vprašanjih razlikoval od predtesta, se je pokazala bistvena razlika v napredovanju, saj je TR dosegel 41,7 %, KR pa 32,5 % rezultat.

Napredek posamezne skupine smo natančneje izmerili tako, da smo izračunali normalizirani napredek:

$$g = \frac{\left(S_{po} - S_{pred}\right)}{\left(1 - S_{pred}\right)},$$

pri čemer predstavlja S_{po} rezultat končnega testa in S_{pred} rezultat predtesta. V skupini TR je bil g = 0,15, v KR pa je bil g = –0,06, kar kaže, da kontrolna skupina v obdobju testiranja ni pokazala napredovanja v razvoju konceptualnega razmišljanja.

V končni test smo dodatno vključili dva problema, ki bi jih naj dijaki in dijakinje reševali s tradicionalnim premetavanjem enačb. Obe skupini sta ta del rešili manj uspešno, zato zaključka o vplivu metode na tak način reševanja problemov nismo uspeli izpeljati.

ZAKLJUČEK

Metoda testiranja, imenovana kolegialno učenje, je pokazala, da lahko pričakujemo že v krajšem časovnem obdobju napredovanje v konceptualnem razmišljanju dijakov in dijakinj. Čeprav je bila kontrolna skupina po predznanju in sposobnostih boljša od testirane skupine, je slednja ob zaključku testiranja pokazala na pomembno razliko v napredovanju glede na kontrolno skupino. Kvalitativni rezultati, ki so težje merljivi in se predvsem upirajo na občutenja vseh vključenih v proces poučevanja, pokažejo, da je ob primerni pripravi motivacijskega terena in ob pozitivni učiteljevi spodbudi mogoče doseči, da se dijakinje in dijaki na uro predhodno pripravijo, kar pozitivno vpliva na dinamiko v razredu.

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