Materials, objects and their properties: Didactical resources for primary science education

Martins, I. P. <u>imartins@dte.ua.pt</u>; Rodrigues, A. V. <u>arodrigues@dte.ua.pt</u>; Nascimento, P. <u>pnascimento@dte.ua.pt</u>; Vieira, R. <u>rvieira@dte.ua.pt</u>

Centro de Investigação em Didáctica e Tecnologia na Formação de Formadores [CIDTFF] Departamento de Didáctica e Tecnologia Educativa (DDTE) Universidade de Aveiro (PORTUGAL)

Introduction

Currently, Portuguese Basic Education is in accordance with the document "National Curriculum of Basic Education - essential competences" ("Currículo Nacional do Ensino Básico – Competências Essenciais") (ME-DEB, 2001). As concerns science education, an STS orientation is *proposed* (Science-Technology-Society), advocating a greater emphasis on scientific literacy. Despite this curricular change, teachers' knowledge, conceptions and practices continue not to follow this orientation (Vieira, 2003; Martins, 2002b).

Therefore, there seems to be national agreement and congruence with international recommendations for a science education reform. Where then are the problems? What is missing that keeps us from achieving these purposes?

A few studies developed in Portugal and in other countries, as well as other sources, illuminate some important factors that can help us understand the actual science teaching practice and the learning situation:

a) deficient teacher training in science education, in general, and in the didactics of science, in particular (Harlen, 2006; Appleton, 2005; Klein, 2005; Harlen & Holroyd, 1995);

b) the great emphasis on other curricular areas (especially Portuguese Language and Mathematics) rather than on Natural and Physical Science (Lakin, 2006; Martins, 2002a; Amadio, 2000);

c) the quality of textbooks (some of which present scientific and methodological mistakes) and the lack of alternative didactical resources to support teachers of science in their classrooms (de Bóo, 2004; Membiela, 2002; Santos, 2001; Sá, 1999).

Based on these concerns and our intention to provide more and better didactical resources, we have been developing, at the University of Aveiro, STS didactical resources to teach and learn science in the early school years. Our present purpose is to present a model developed at the Open Laboratory of Science Education (*Laboratório Aberto de Educação em Ciências* – LeduC), located at the Department of Didactics and Educational Technology, University of Aveiro, to produce these didactical resources within the framework of *Materials*, *Objects and their Properties*.

Why materials, objects and theih properties?

Materials and objects have always been a part of human life. We sometimes use them without questioning where they come from, what is involved in their obtainment, whether or not they are finite resources, what their environmental impact is and what the consequences of using them are for future generations.

The didactic exploration of materials has been considered in formal teaching programmes linked mainly to the field of chemistry, which stresses in its approach the conceptual perspective of materials' constitution and ways of representing them and, in the case of synthetic materials, their respective synthesis reactions. Less common is manipulation of the materials themselves to get a macroscopic view of them, and rarely developed are the technological aspects associated with their industrial preparation, recovery and recycling processes.

Regarding the objects the materials are destined for, the outlook on them as simple applications of materials predominates, which contradicts the technical-scientific, socio-technologic and socio-scientific dimensions with which we can view scientific knowledge and on which the STS orientation for science education is based, as is foreseen in the Portuguese curriculum (ME-DEB, 2001). In fact, such a distorted view of concepts (materials) and their applications (objects) ignores the fact that, in modern developed societies, materials are the fruits of research conducted to meet society's needs.

Despite the importance of materials in everyday life, they are not given the attention they deserve in formal education. The approaches used in textbooks designed for Basic Education (6-10 years, in Portugal) are poor and fail to make a clear distinction between materials and the objects made from them.

Nevertheless, our perception of the world begins early in life. This is why it is essential that didactic teaching strategies, concerning the diversity around us, make use of contexts familiar to children so that we can capture their attention and develop their critical and creative thinking and curiosity.

Given the above, it is very important to develop didactic strategies and activities that can promote these abilities and to use an approach that will enable children to, among other things, (i) perceive the huge variety of materials existing around them; (ii) distinguish the concepts of material and object; (iii) understand that objects used every day are made from one or more materials, combined in different ways depending on their use; (iv) recognize the importance of wisely using materials that guarantee sustainable development in the world.

We consider that understanding materials and how to use them wisely will definitely allow children, citizens of the future, to apply the scientific and technological knowledge that will help them make the right decisions, not only personal but also social, in a responsible and conscious way.

Didactical resources conception – which model?

In our conceptualization, a didactical resource should be a concrete support capable of embodying declared ideas, which are constituted, in a social-constructivist perspective, by activities that require the student to be active. Thus, we consider that didactical resources are essential elements of science teaching organization: They are used not only to help children achieve significant learning, during their active exploration, but also to help teachers promote, through their practices, constructive strategies and activities that implicate children in the development of their own skills with a view to scientific literacy.

The didactical resources conception model used in LEduC includes four stages:

1. Topic selection and document-based research and analysis

Deciding on a theme, which may include selection of socially important groups of materials and scopes of application (plastic and metals, for example), presupposes diverse readings and a critical look at reality. Another basic aspect is the age level for which didactical resources are designed. Document-based research and analysis cut across all the processes of planning, conception and validation of didactical resources. However, the stage that follows topic selection demands particular emphasis on the diversified nature of document analysis (curricula, textbooks, national and international research papers, etc.), in order to proceed to the curricular framing of the topic; to the identification of teaching

approaches and proposed strategies, and their respective shortcomings; to the topic's importance, as well as the scientific and didactic knowledge inherent in it.

2. Identification of children's conceptions/ideas about the topic

Given the importance of starting from children's previous understandings, it is fundamental to understand what children think about the topic, if we are to identify underlying alternative conceptions to their ideas. This is also a way to establish children's difficulties/needs, interests and curiosities regarding the topic. To accomplish this, data are collected from the literature and/or smaller research projects (validated by experts) are carried out near the children themselves. This stage is the basis for the next.

3. Conception and construction of didactical resources to approach the topic

There are some aspects of the conception of didactical resources that are important to highlight, namely: (i) select wisely what is to be learned and what practical skills are to be developed; (ii) give priority to studying problem situations of interest to children in an STS context; (iii) enable laboratory activities, especially investigations; (iv) develop varied didactic teaching strategies with flexible exploration that stimulate children to apply knowledge and to use their thinking skills; and (v) when possible, encourage use of the New Technologies of Information and Communication (NTIC).

Didactical resources present versatile and diverse formats and have underlying safety principles concerning the handling of some materials. They include devices, samples of materials, current use of objects, organized according to tasks to be carried out by the children, with a degree of openness that is adjustable to their cognitive development and previous knowledge. They also include guiding documents for children (in which the tasks to be done and the necessary registry sheets are included) and for teachers (including the presentation of activities, goals, abilities, work methodology, materials and resources to use, as well as orientation and exploration suggestions).

4. Didactical resources validation

First, the validation of didactical resources is made by an expert panel, consisting of primary school teachers as well as science didactics specialists, to evaluate their potential as concerns the focused contents, learning objectives and skills, the adequacy of the strategies, the clarity of methodological orientations and eventual limitations.

Subsequently, they are validated in a real-life context with children in the age group the resources were designed for, in the course of activity sessions in the classroom and in nonformal sessions for children and their teachers, which take place in LEduC or in the classroom. The main objective is to evaluate children's reactions during their exploration of the conceived activities and their learning progress as well as to standardize some aspects considered relevant (the adequacy of the proposals, expected time, safety and didactic exploration, for instance).

Data collecting for validation is accomplished through observation of the video-taped sessions/classes and through analysis of the registries made either by the children or by the teachers.

Table 1 presents some didactical resources developed in LEduC around the theme *Materials, Objects and their Properties*.

Table 1: Examples of didactical resources developed to explore the topic Materials,

 Objects and their Properties.

THEME	TOPIC	CONTENTS/PROBLEM SITUATIONS
Materials, Objects and their Properties	Materials trip: from substance to object	 Materials trip. Solid or liquid. The natural world. The origin of materials. The properties of materials.
	<i>Materials: diversity, properties and transformations</i>	 Discovering materials by touch. Extracting materials. Observing materials. Producing materials.
	Plastics: what do children think about them	 Am I made of plastic or not? Are we all identical?
	Textile Fibres: understand fibres and fabrics	 How to treat them? Understanding labels. Weaving and unravelling. Can I change my colour? Where do I come from? Are we all permeable?
	<i>Metals and Alloys:</i> special materials for life	 Metals and other materials! Identify these metals! Know aluminium! From ore to object What are the properties of metals? Are we all equally vulnerable to metals? Cleaning metals!
	Paper and papers: diversity and properties	 Can we transform old paper into new paper? Am I made of paper? Which is the paper that absorbs better or worst? Do our properties change after being covered? Which of us is the most resistant?

Final considerations

The developed didactical resources have been requested both by schools, where educators/teachers can explore them in the classroom with their children (formal context), and by other institutions (independent science centres, for instance) that intend to promote science discovery activities, such as science and technology weeks or science fairs (non-formal context).

These didactical resources are also applied in initial, continuous and post-graduate training of primary school teachers and nurse educators, allowing them to become familiar with the resources, learn how to explore them with children, and stimulate interest by coming

up with new resources in different curricular areas. On the other hand, didactical resources have also been the subject of a great deal of research in the area of science education.

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