DEVELOPMENT OF DIGITAL EDUCATIONAL RESOURCES FOR EDUCATION FOR SUSTAINABLE DEVELOPMENT: THE *COURSEWARE* SERE

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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.

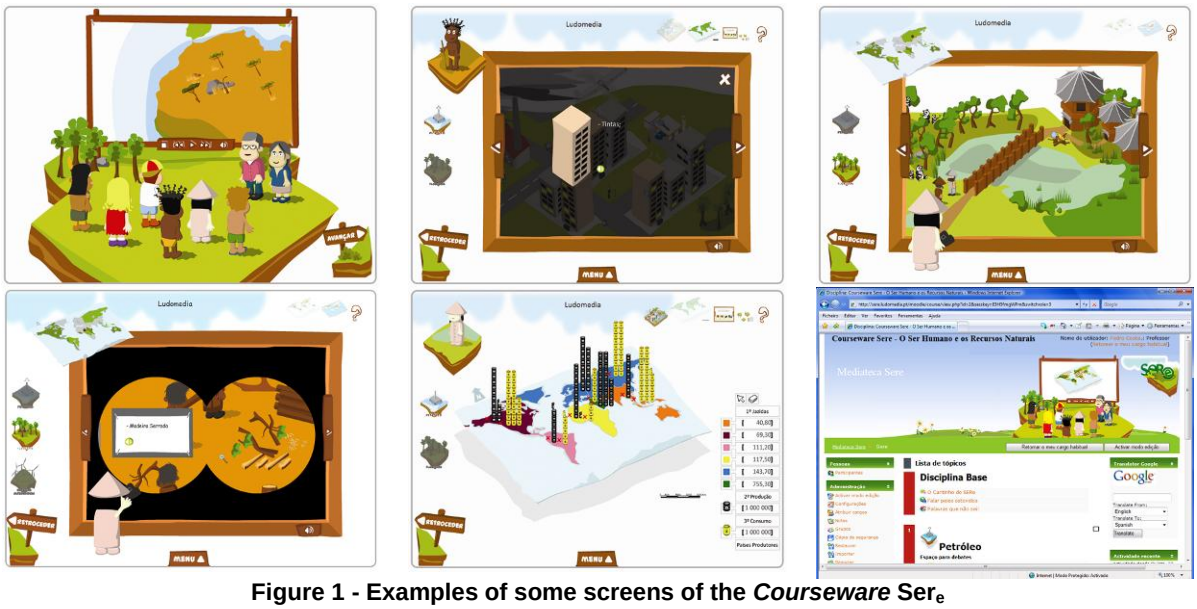

Figure 1 - Examples of some screens of the *Courseware* Ser_e

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.

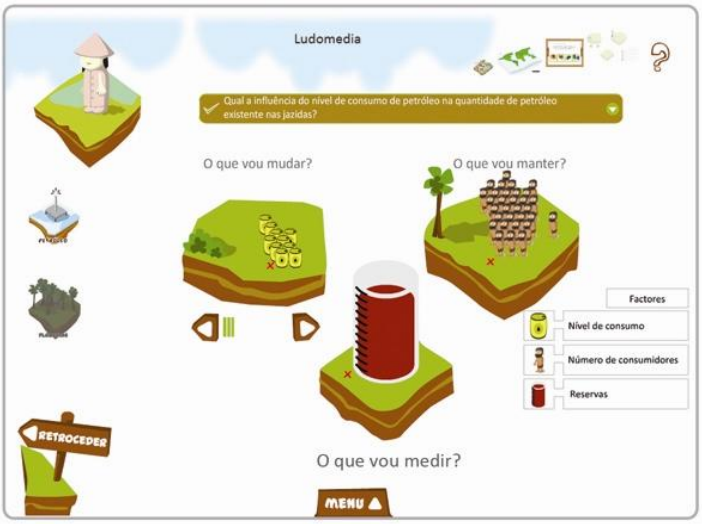

Figure 3 – Oil consumption simulation

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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