INTERACTIVE, COLLABORATIVE AND ADAPTATIVE LEARNING TOOLS
The TexMat Example

A. M. Breda, E. M. Rocha and M. M. Rodrigues
Department of Mathematic, University of Aveiro, Campus Universitario de Santiago, 3810 - 193 Aveiro, Portugal

Keywords: Learning and adaptive systems (68T05), knowledge representation (68T30), knowledge-based systems (68T35), technological tools and other materials in teaching and learning (97C80), student learning and thinking (97C30), sociological aspects of learning (97C60).

Abstract: The purpose of this paper is to describe a model for long distance learning/teaching tools that uses the World Wide Web (WWW) as a vehicle for the design and delivery of a learning/teaching environments in the context of mathematics basic education. We will illustrate such applications through TexMat, aimed specifically for the 5th and 6th grades of Basic Portuguese School - 10 to 12 years old youths. The goal of these tools is to paint a bigger vision of how technology can impact learning, teaching and training. We begin by giving an overview of the general principles underlying these applications, emphasizing the understanding of how cultural, cognitive and technological tools shape a support learning and knowing environment. A concrete example is also present.

1 INTRODUCTION

In general, new technologies tend to replace old ones, or to be quite different from them. We accept as true, that some old media, as standard paper books, have significant impact in the way information is transmitted. A paper book is a linear and sequential structure that is very well organized, usually, have a table of contents and an index. In opposite, web applications/websites have by nature a graph structure, giving the user a nonlinear navigation experience.

In this paper, we begin by giving an explanation of instructional and cognitive principles underlying the conception of an educational software, followed by an exploration of learning technologies and collaborative environments, leaving the details of the adaptation of learning environments for section 4. In section 5, we enumerate graphic principles for design makers. Being section 6 devoted to technical features we finalize with some conclusions and future work.

TexMat is an interactive mathematical web application planned for 5th and 6th grades (10 to 12 years old youths) of the National Curriculum of the Portuguese Basic Education in Mathematics. It has several interesting features (e.g., the Notebook, and the Agent Application) and employs dynamic user evaluation (content and behavior) in order to allow the dynamic training to adapt to each user needs. In its design, concrete instructional, cognitive, and graphic principles have been taken in consideration, e.g., in the development of the geometry units, we have followed the Duval's theoretical framework (Duval, 1998), with respect to the cognitive processes involved in the geometrical reasoning. In TexMat, all pages are composed using *Macromedia Flash* and *xHTML+Javascript*, giving it a high level of interactivity and animation. The electronic book is controlled by *WebApplications* and *WebServices* developed in *C#.NET*. The book has also two operation modes: a student mode and a teacher mode, where he/she may check students performance and interact with the students.

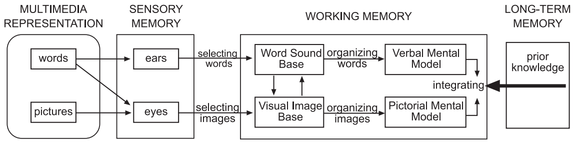

Figure 1: Representation of a cognitive theory of multimedia learning.

The TexMat's project had the collaboration of several graduate people with skills in Design, Programming, and Pedagogical Education.

M. Breda A., M. Rocha E. and M. Rodrigues M. (2008).
INTERACTIVE, COLLABORATIVE AND ADAPTATIVE LEARNING TOOLS - The TexMat Example.
In *Proceedings of the Fourth International Conference on Web Information Systems and Technologies*, pages 456-459
DOI: 10.5220/0001517904560459

2 INSTRUCTIONAL AND COGNITIVE PRINCIPLES

The cognitive architecture for information processing is relevant to adequate the content presentation and to maximize the assimilation process.

Cognitive load theorists believe that intrinsic, extraneous and germane cognitive loads are additive, in the sense that, together the total load cannot exceed the working memory resources available if learning is to occur (Pass, 2003).

Next we shall enumerate principles for instructional design makers having in consideration the load cognitive theory.

Multimedia Principle. It is better to present an explanation making use of two modes of representation, words and pictures, in an appropriated combination (improving conceptual understanding and quality of information processing than one, (Mayer, 1997) and (Clark, 2003).

TextMat book appears inhabited by four characters - animated bookworms, the agents that will guide the student trough each thematic unit. They will give the feedback of the actions of the student and help him/her if he ever feels lost. Each agent has its own personality and a different occupation that represents the application of the contents to real life situations.

Contiguity Principle. An explanation containing words and pictures is better understood when they are presented at the same time. Since corresponding words and pictures are in the working memory at the same time, schema formation may take place, (Mayer, 1997). In the TextMat book several explanations contain simultaneously text and (animated) pictures, (Clark, 2003).

Figure 2: When the learner touches the butterfly an animation shows its symmetry axe.

Modality (split-attention) Principle. When given a multimedia explanation avoid splitting the user's attention by using multiple sources of mutually referring information, (Mayer, 1997). Modality principle asserts that verbal information is better understood when it is presented in a narration instead in a visual on-screen text. It is a way to prevent an overload of visual information.

Redundancy Principle. This principle states that users learn better from animation and narration than from animation, narration and text if the visual information is presented simultaneously to the verbal information. Multiple representation increases extraneous cognitive load,

Spatial Contiguity Principle. Users learn better when on-screen text and animations are physically integrated rather than separated, (Smith, 2004).

Individual Differences Principle. This principal is based on the assumption that multimedia, contiguity and split-attention effects depend on the user's personal characteristics. Users who lack prior knowledge tend to show stronger effects than the ones who possess high levels of prior knowledge, (Mayer, 1997). Allowances for varied learning styles should be integrated into the instructional design.

Learner Dynamics Principle. A conceptual distinction should be made between applications which are essentially content delivery (learners progress through the educational materials in a traditional way) and applications containing exploration of nature components (high interactive, with simulations, games etc.). In TextMat book the learner deduces an expression for the area of a circle of radius r, simulating the division of the circle in equal parts.

Mediation Principle. Another aspect that has a profound effect on the way the learning occurs is related to the structure of the activities (tasks) proposed. The ITS must give to the learner the opportunity to solve problems, draw conclusions, compare options and think about what he/she is doing. In TextMat book activities are randomly generated and categorized in three classes: reproduction (problems whose solution is a direct application of concepts and procedures), connection (problems requiring effortless routines involving distinct concepts) and reflection (non trivial problems involving more than one concept).

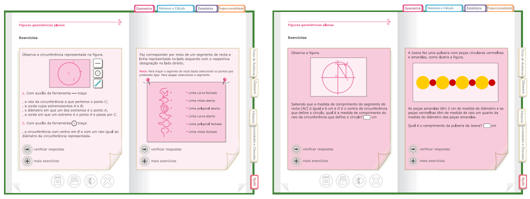

Figure 3: Exercises with different levels of difficulty.

Coherence Principle. Students learn better when extraneous material is excluded rather than included in multimedia explanations, (Mayer, 1997). During the TextMat book sometimes we introduce some funny elements to seduce the user at the same time they assist the explanation. Several examples appear with many illustrations and animations used to increase the dynamism and refresh the speech.

3 LEARNING TECHNOLOGIES AND COLLABORATIVE ENVIRONMENTS

Clearly, learning is not a process of transmitting information from someone who knows to someone who doesn't; rather, learning is an active process on the part of the learner, where knowledge and understanding is constructed by the learner. Moreover, learning is a social process: learning proceeds by and through conversations. Learning is mediated by the construction of external artefact, where the construction of artefact leads to the construction of understanding.

3.1 Learning Management Systems

Learning management systems (LMS) usually complement or replace the traditional classroom activities and interaction students/teacher, e.g., giving mechanisms to disseminate digital based courses. They also provide tools and facilities for online course management, content management and sharing, assessment management, and online collaboration and communication. Nowadays, there are several examples of software bundles that implement the above features. A commercial example is the *Blackboard* (see http://www.blackboard.com, http://www.blackboard.com), a web-based software system which is used to support flexible teaching and learning in face-to-face and distance courses. Another example, it is the open source software *Moodle*, the acronym of *Modulating Object-Oriented Dynamic Learning* (see http://moodle.org, http://moodle.org). Those systems have been also named as *distance learning systems*, or either, as *systems of management of learning in collaborative work*.

3.2 Interactive Multimedia-based Learning Systems

Any interactive multimedia educational software relies on a varied blend of multiple means such as text, graphics, animations, audio, video, etc., only achievable by the development of technological tools. In turn, it was the growth of interest in interactive open systems that lead to new technological developments. A deep dynamic interaction between technology and interactive multimedia-based learning has been established.

3.3 Collaborative Environments

The Internet became by excellence the infrastructure of telecommunications and sharing. With the advent of the broadband, with the technological advances in terms of capacity of processing and data technologies had been made possible that allow to the interaction between diverse users in real time the great distance to a low cost. The video-conference systems allow, of a practical and efficient form the accomplishment of events between multiple people allowing an increase in the efficiency and reduction of costs and time.

Streaming and videoconferencing technologies are getting widely common. They may enrich considerable the experience of students learning. In TexMat we intend to give the possibility to a student, studying without survilence", to be able to contact someone able to clarify any questions he/she may have related with the TexMat lesson he/she is studying at the moment. For that, we have made several trials with the opensource JSummit, the Skype API and the opensource AccessGrid.

The AcessGrid is one project that it allows the video-conference on IP using multicast. It has as goal to supply a sufficiently rich environment of contribution of groups and involves great groups of participants with a diversified distribution. One intends that the TexMat software behave as AcessGrid client

4 AN ADAPTATIVE LEARNING ENVIRONMENT

E-learning paradigms and implementations have brought many advantages to technology-based distance education as pointed out in (ADL 2001). In addition, e-learning was identified as one of the emerging areas in the last few years as shown by means of concrete numbers in an IDC study (IDC 2003). On the one hand, e-learning enables identifying, analyzing and monitoring relevant aspects of instructions, such as strategies of learning.

Book's Navigation. The user's navigation in an IntBook is defined by a XML file, that contains information about the content structure. On use, a personal navigation file is created for each user in order to adapt the book to the user answers to the book's questions (exercises) and their last seen pages. In this case, each user will have their personal navigation model (nonlinear structure). An improvement can be achieved using Expert Systems (artificial intelligence systems), with a knowledge base and a well-defined set of production rules, in order to generate a best suited personal navigation file. Although this mechanism is not yet implemented, it is a strong possibility of future work.

5 GRAPHIC DESIGN PRINCIPLES

Finding the balance between the mathematical content and an enjoyable learning experience for the students is not easy. Rachel S. Smith (Smith, 2004) presents a group of guidelines to have in consideration when designing the learner's experience in terms of graphic design and usability as we explain in the next section.

Balanced Design Principle. The graphic design of the interface involves a lot of choices considering the layout, colors, navigational elements and user controls, as it defines the way the student will access the content.

TexMat, following the Mathematics National Curriculum of the Portuguese Basic Education, is divided in four study units: geometry; numbers and calculus; statistics and direct proportionality. We have associated to each of these units a different color. The layout of each unit and sub-units is similar in terms of shapes, fonts and sizes, being the distinguishable element the color scheme. TextMat presents a structure similar to a book, where the navigation is made by the turn of pages and every concept is presented in a new page, exactly the same way as it happens in traditional didactic materials. Inside, each page has a vertical area for the contents, which remains identical in the entire book. It has also a clear buttons area. On the right side are the buttons to access to the learning help tools (glossary, notebook, evaluation sheets) and on the top the ones that link the user to the different units. In the page on the left are the buttons that operate in the current page ("add to the notebook", "print", "sound ON/OFF" an "quit"). The contents are explained to the student textually, next to different and easily identifiable areas where will appear the animations and video that illustrate the text.

Another key aspect is to give the student the feeling that he is in control of the book. If all the pages provide a clear navigation and allow the student to stop, restart, skip or revisit animations and videos, it is more likely that he will explore the book because he knows he won't feel lost. Besides, the student should never feel trapped, he/she should have a clear way out. In TextMat book when the user access to the notebook, he/she (while progressing in learning) may insert, in a condensed way, definitions, principles, concepts, properties, theorems, formulas, schemes, etc. building a personal study guide of quick access. As naturally expected, the user may access whenever he/she feels up his/her notebook to consult, insert, modify or erase information.

6 LANGUAGE AND STRUCTURE

In order to get the desired aggregation of the different web technologies we define a specific language (file format) designated *IBK*, specified in the XML format. A book is represented by an IBK package – that is a IBK file, containing all the structure information needed to build an IntBook, together with a set of resources (external files). The IBK file (the main file) is composed of a header and a body section. The header section contains metadata about the file, authors, book's layout (single/double page), language settings (default and translating languages), list of resources and tuning options as latex compile parameters. The body section contains the book content – text and objects/components that will dynamically generate the set of pages. The main text allows the full use of $\LaTeX$ and may have embedded objects that are building blocks of a page (Flash, Java-Applets, HTML, etc.). Objects are embed in the body section using simple IntBooks commands, which greatly simply the build process to authors which do not need to be aware of the technology used. In the future, it may also allow authors to seamless incorporate blocks of text (as theorems) in their texts, available in some kind of "text pieces" library.

REFERENCES

Clark, C. & Mayer, R. E. (2003). E-learning and the science of instruction. In *Markwell Biochemistry and Molecular Biology Education, 31*.

Duval, R. (1998). Geometry from a cognitive point of view. In *Perspectives on the Teaching of Geometry for the 21st Century*.

Mayer, R. E., . M. R. (1997). *A cognitive theory of multimedia learning: Implications for design principles*. Wiley, New York.

Pass, F., R. A. . S. J. (2003). Cognitive load theory and instructional design: recent developments. In *Educational Psychologist, 38*.

Smith, R. S. (2004). Guidelines for authors of learning objects. In *The New Media Consortium*.