TexMat: A Multimedia Constructivist Learning Environment

Ana Breda[1]
ambreda@mat.ua.pt

Eugénio Rocha[1]
eugenio@mat.ua.pt

José Martins[1]
jmartins@mat.ua.pt

Abstract: The *World Wide Web* has increased extraordinarily the level of communications and collaborations among people via technology. As a consequence the use of computer systems in the teaching and learning processes has in the last few years moved to a new form of technology-supported instruction: *web-based instruction*. Web-based instruction is rapidly becoming one of the major sources to deliver courses to students ([2], [15], [16]). Besides the facility to communicate and collaborate with other students [11], one of the reasons for this fast increasing system of instruction delivery is its cost-effective.
Mathematics is a privileged subject to take advantage of the internet potential. It is a subject area with a recognized hierarchy of topics, which can be introduced with varying degrees of depth to a wide range of users. *TextMat* is an interdisciplinary academic project whose objective is the development (conception and implementation) of a maths web-based electronic textbook, i.e. an application with a multimedia database enhanced by instructional resources [12].
As referred in ([3], [10]), online learning is a social experience. The flexibility offered by online technologies support needs of different learners. In online learning research the study of new constructivist learning strategies is a vital issue including the ones reported by Hughes and Daykin [8], Sims [14] and Alexander et al [1].
This paper concentrates in the theoretical framework underlying the pedagogical design of *TexMat*, a multimedia constructivist math learning environment. It comprises four main components: the tutorial-project space, the problem--project space, the collaboration space and the assessment-project space, enclosed in the student's and educator's spaces. Underlying these spaces were produced cognitive tools with the purpose to support the learner's exploration, inference, reflection, social interaction to construct their knowledge, [9]. We shall made use of a virtual agent whose purpose is to guide the users in their learning, having in account their performances.

1. Introduction

The World Wide Web has emerged as a user friendly system for accessing information and communication resources in the internet. The rapid progress of computers and network techniques, led online learning to be an important and unavoidable learning tool. Nowadays, the use of online instruction as a mean of schooling is a certitude. Computer assisted learning turned progressively more on web based training creating a new area of research were *computer-mediated-communication* is without any doubt one of the vital issues for educators, considering online distance and remote learning, in the 21st century.

In this paper it will be described some general principals underlying the design, with particular focuses in the pedagogical design (embedded in a constructivist learning environment) of the web course *TexMat* a mathematical course planned for 5th and 6th grades of Basic Portuguese School (10 to 12 years old youths). *TexMat* can be viewed as an intelligent interactive structured

[1] Department of Mathematics, University of Aveiro, Portugal

collection of educational tools (text, animations, videos, chat channel) providing an active and participative self, coach or collaborative learning with pedagogical interactions of type: *student-originate actions* (exploration of units of knowledge, information and/or help request, problem solving) and *educator-originate actions* (help and recommendations, monitoring, assessment).

The development of *TexMat* has been carried out in the context of *Geometrix*, an interdisciplinary project, involving mathematicians, informatics and designers whose target is the development of specific structural computer designs for the teaching and learning of mathematics.

2. *TexMat* General Design Principles

Obviously, the design of a web courseware has a great influence on the teaching/learning processes. In [18], were described some expected properties and factors that should be considered in the designing of a web course. A summary of these properties and factors are given in the following table.

FACTOR / PROPERTY	Information Resources	Content Organization	Course Structure	Course Navigation	Content Representation
Reflecting the current trend in the development of discipline	■	■			
Structure and content of course could be easily extended	■	■	■		
Prompt student's motivation	■			■	
Different user's sharing of the resources		■			
Easy Interaction			■	■	■
Endorses collaboration					■

Table 2.1 Properties and factors that must be part of a web course

Let us present a brief commentary based in the above table reading. As specified, the choice of information recourses as well as the content organization of the course must reflect the current trend. Naturally, this property has a real meaning for high school or university level courses. The structure and content must support extensions, without any difficulty, sustaining other course related units in a dynamic and layered way without bringing complexity to the choice of information resources. Besides, the selection of information resources and the navigation within the courseware should be useful for pushing user's motivation in active and self learning. According to the nature of the web course its architecture must allow interactions between human-machine, teacher-machine-student and student-machine-student. With respect to collaboration, the

representation of the course content must contain learning tasks that could be fulfilled by cooperation.

When designing a web courseware another important aspect to have in mind is related to the learning styles adopted by the course. It is expected that some of the four meaningful learning styles must be present: *concrete experience* (feeling); *abstract conceptualization* (thinking), *reflective observation* (watching) and *active experimentation* (doing), [17]. Depending on the environment and the user's personal features, a learner may prefer one learning style to another but as stated by Feldman [5], learning will be greatly enhanced if one is actively involved in all of them. This can be achieved adding text notes, illustrated examples, interactive or animated demonstrations, quick quizzes, self-tests, etc., functionalities that are present in the courseware as we shall show in the next section.

The way the instructional materials are organized has an enormous influence in the learning efficacy. For the user is better to interact with a course divided in units of knowledge (subsections), which can be associated in blocks (sections) and these in bigger blocks (topics).

We may identify in *TexMat* two distinct block structures: the user block (student's and educator's spaces) and the knowledge block. In figure 2.2 is sketched the block structure adopted for *TexMat.*

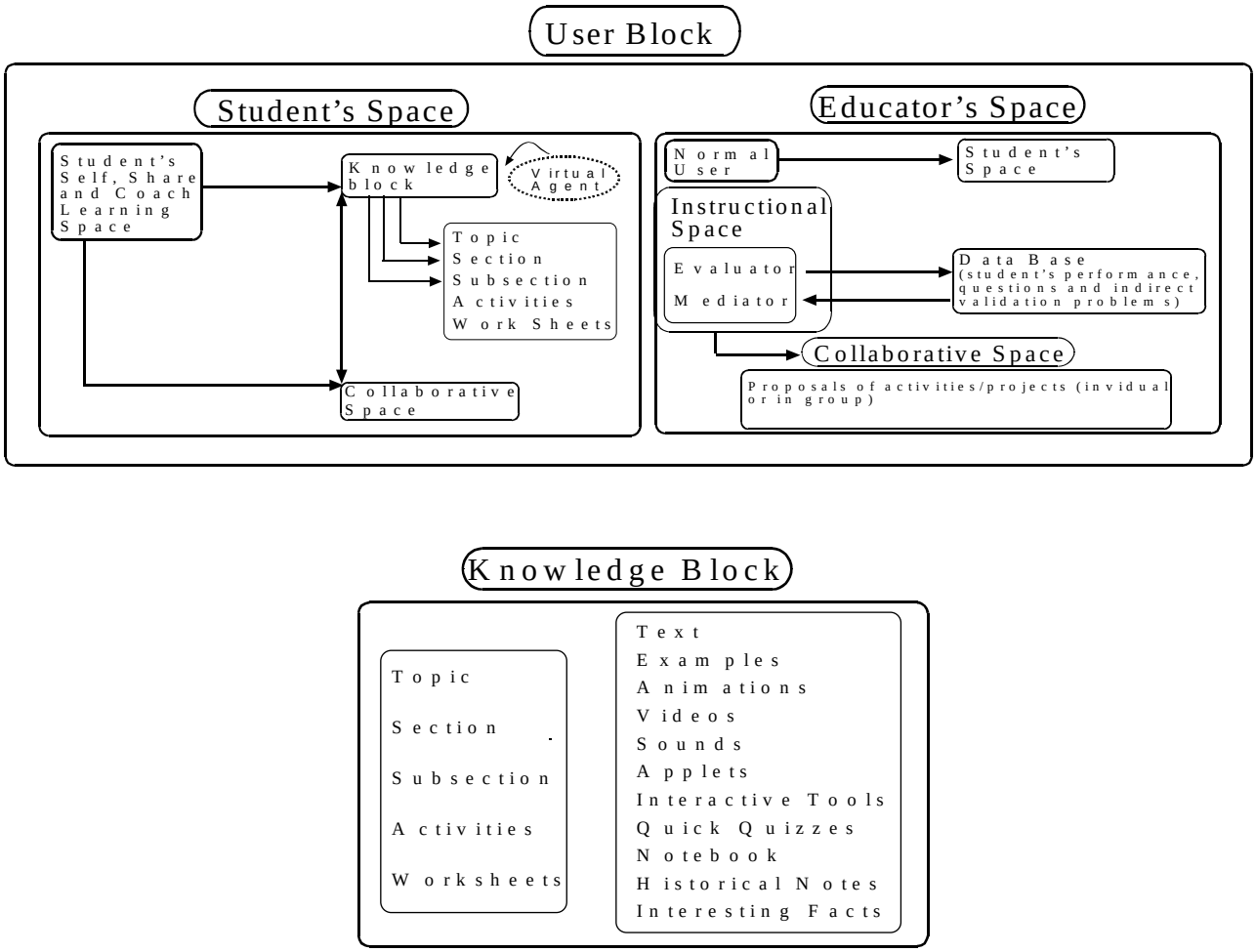

Figure 2.2 *TexMat*'s block structure

3. *TexMat* Block Structure

The *TexMat's* contents follow the Mathematics National Curriculum of the Portuguese Basic Education for 5th and 6th grades. They are grouped in four topics: Geometry (G); Numbers and Calculus (NC); Statistics(S) and Direct Proportionality (DP).

The user block is composed by the student's space (learning environment) and the educator's space (instructional environment).

In student's space the four topics (G, NC, S, DP) are available for users. The choice of one of these topics makes accessible the knowledge block. The students may access to the collaborative space (chat channel or e-mail) to communicate with other peers or/and his/her teacher for discussing ideas and questions and to share knowledge or to receive instructions (activities/projects proposals) from the teacher.

The knowledge block is formed by the content of the web course, animations, audio/video, applets, quick quizzes, a notebook, activities (open-ended problems), worksheets (randomly generated), historical notes and interesting facts.

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.

The activities (randomly generated) are 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). The worksheets are generated upon the choice of some (sub)units of knowledge and are composed by questions of automatic validation.

The interaction between the user and the knowledge block is ruled by a virtual agent who acts, under certain circumstances, as an advisor in the user's navigation.

In figure 3.1 it is illustrated the *TexMat* layout (a classical book), the virtual agent (the friendly user's partner) and the notebook (a personal summary of the essentials of the subject mater).

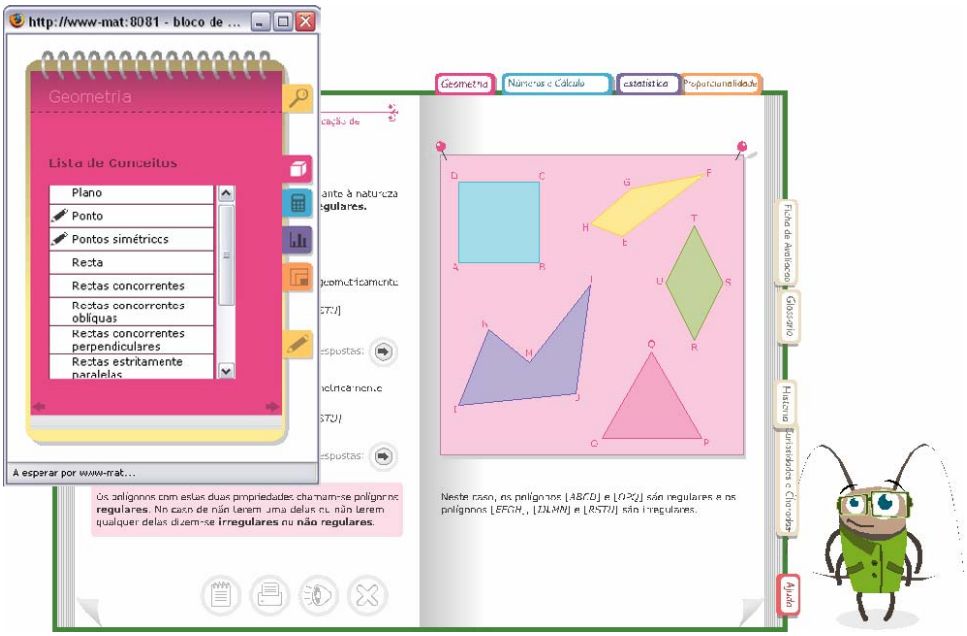

Figure 3.1 *TexMat*'s layout, the virtual agent and the notebook

The educator's space is designed to be used by teachers and parents. An educator must choose one of the following options: access to the student's space (as a normal user) or to the instruction space. If the access is through the student's space, the educator has exactly the same permissions as a student. If the access is through the instruction space he/she may interact with the software either as a mediator or as an evaluator. Here, the educator has the possibility: (1) to analyse the results stored in a data base related to his student's performance; (2) to receive for validation open answers (connection/reflexion problems) related to *TexMat* activities and; (3) to send proposals of tasks or activities for a specific student or for a group of students.

The structure and content organization of *TexMat* could be easily extended in the sense that it is an open system. Not having in account the amount of routinary technical work, it is, roughly, a question of adding new (sub)topics, activities, applets, etc..

TextMat can be navigated linearly as in a classical book, with the advantage of having the index quickly accessible, permitting a direct jump to a specific (sub)topic. On the other hand, the nonlinear navigation capability is one of its advantages over classical books, and can greatly improve the students learning experience. A virtual agent acts as a facilitator in the navigation, advising the best possible paths of navigation having in account the user's performance.

4. A Constructivist Learning Environment

TexMat promotes a constructivist learning environment in which the learners construct actively their own knowledge on the basis of their experiences.

The constructivist theory goes back to the XVIII century with I. Kant and Giambattista Vico. Piaget (cognitive constructivist) and Vigotsky (social constructivist) are well known followers of this theory. While Piaget advocates that knowledge acquisition is an adaptive process and results from active cognizing by the individual learner, Vigotsky beliefs that knowledge is the result of social interactions and language usage and thus is a shared, rather than an individual experience, [13].

In [7] is given a list of nine critical criteria that could be used to guide the design and development of an interactive multimedia program for comprising a constructivist shell for the learning of research methodology. The program needed to provide:

1. *An authentic context that reflects the way the knowledge will be used in real life;*
2. *Authentic activities;*
3. *Access to expert performances and the modeling of processes;*
4. *Multiple roles and perspectives;*
5. *Reflection;*
6. *Collaborative construction of knowledge;*
7. *Articulation;*
8. *Coaching and scaffolding;*
9. *Authentic assessment.*

The first two points can be found not only in the room environment corresponding to a specific topic, where a folder containing projects involving activities that have real-world relevance but also in the *TexMat*'s activities.

The third point is given by videos and animations present throughout the courseware. The last point has a local meaning through the quick quizzes and a global one through the automatic validation problems. The remaining points are functionalities of the collaborative space.

Having in account these criteria *TexMat* can be considered a constructivist multimedia learning environment. The conditions for a pilot study with a group of 20-25 students are now

fulfilled. During the next two years we intent to follow the students to analyse the learning effects due to their interaction with *TexMat*.

TexMat was conceived having the constructivist model as the underlying learning theory. However the collaborative space, were the educator can act as a mediator, can be used having any other learning theory (as the ones mentioned in [6]) in mind.

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