COGNITIVE APPROACH TO E-LEARNING IN SCIENCES AND TECHNOLOGIES

Safwan El Assad, Velina Slavova, Gilles Nachouki

Abstract: This article describes the approach adopted and the results obtained by the international team developing WBLST (Web Based Learning in Sciences and Technologies) a Web-based application for e-learning, developed for the students of "UVPL: Université Virtuelle des Pays de la Loire". The developed e-learning system covers three levels of learning activities - content, exercises, and laboratory. The delivery model is designed to operate with domain concepts as relevant providers of semantic links. The aim is to facilitate the overview and to help the establishment of a mental map of the learning material. The implemented system is strongly based on the organization of the instruction in virtual classes. The obtained quality of the system is evaluated on the bases of feedback form students and professors.

Keywords: learning assistance trough domain concepts, virtual classes.

ACM Classification Keywords: K.3.2 Computer and Information Science Education

Introduction

Several factors have led to the widespread adoption of on-line learning, but the Web-accessibility of exposed learning material does not give any guarantee about the efficiency of learning. The added value which educational technologies may bring to education is predetermined by the manner in which the technological tools and resources are used for the objectives of instruction. That requires reinforcing the influence of distance learning theory upon instructional design and delivery and redefining the roles of the participants in education.

The analyses of on-line learning have led to the conclusion that the essential discussion should be: how can a learning process be turned into a model? Several case studies [Altun (2000), Psaromiligkos and Retalis (2003), Weiner (2003)] demonstrate that the delivery model itself is a crucial factor for the effectiveness of the learning system. The delivery model embodies the conceptual part of an e-course, which realizes its teaching strategy. The teaching strategy has to be chosen with respect of the cognitive particularities of e-learning, the specific subject material, the technological possibilities of the used systems etc. After analyzing these factors for years, Barker et al. (2003) came to the conclusion that a fundamental requirement of an electronic performance support system is that it should increase learners' training performance by enabling them to "learn as they do". Naturally, in the context of e-learning systems, that requires the establishment of a corresponding delivery model.

In on-line learning, the learner is left alone with the subject material. This requires an approach matched with the theoretical model of learning, proposed by Min et al. (2000), where the process of learning is considered as a student's activity, and instruction as a relatively static condition. However, in order to take on some of the lecturer's functions, the learning material has to behave actively and to "react" in an intelligible, autonomous way. The creation of an autonomous learning system requires the identification of the mechanisms of acquisition and a presentation of the learning material with respect to its essential cognitive ingredients.

The Importance of Concepts and Relations. A well-known theoretical statement is that the acquisition of scientific knowledge strongly relies on the creation of a mental image of the domain's system of concepts and inter-concept relations [Barsalou, 1992]. The acquisition of structural knowledge is typically related to the internal meaningful-interpretation of new concepts, including their incorporation into the edifice of already known concepts. In traditional face-to-face instruction, the exposition of the material is linear; in any case, the lecturer explains it during a given length of time. From the learner's point of view, the process of new concept acquisition demands several "back steps" over the system of new concepts, in other words – it requires some sort of non-linear process of knowledge clarification.

Within an autonomous learning tool, it is the system itself, which has to ensure these functions. The system is supposed to give access to different, semantically consistent teaching sequences, by using static substance "pieces" of textual and schematic explanations, covering different levels of instructing "one and the same thing". That requires a dynamic behavior of the system. In the last few years, a lot of efforts have concentrated on dynamic learning environment, related to metadata models [Lytras, Pouloudi and Poulymenakou (2002), Alpert (2003)]. Some of the successful attempts associate concepts' issues with the system's components, which technologically ensure dynamic behavior. The generation of learning occurrences has to be based on rules, which guarantee the semantic texture of the result. In the system presented here, it is assumed that consistency of the material might be attained through the links, provided by the concepts and their inter-concepts relations. The appropriate method for the achievement of such a task requires a division of the textual-graphics substance of the subject material into smaller units and, on this basis the generation of learning occurrences by using the organization of concepts and inter-concept relations.

General Scheme of the Underlying Model

As it is generally done, the course material is organized in a hierarchical tree-like structure. The linear learning material is divided, as usually, into chapters, sub-chapters and so on. That division leads to smaller pieces of linear learning material - the so-called "learning modules". Inside of each learning module, the corresponding learning material (texts and graphics) is sub-divided into smaller units (Figure 1.). Units are the basic atomic substance with which the system operates. From a semantic point of view, a unit represents a more or less autonomous announcement, and from the point of view of the matter – it is a piece of text (often consisting of one or a few paragraphs) or one scheme.

Titles and subtitles are semantic entities. In view of their further use as building material for dynamic generation, they form distinct units. All units are labeled according to their order in the linear course with respect of its hierarchical organization. This labeling makes it possible to reconstruct the learning material in its "teaching" order.

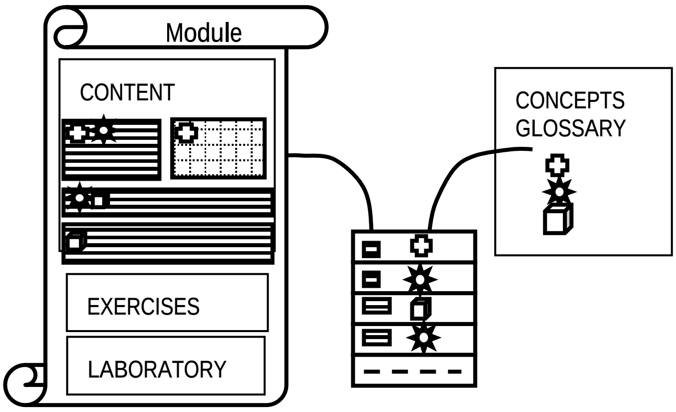

Figure 1. Learning module – units and relationships with the concepts glossary

New concepts and important old concepts are specified, with their definitions, in a concepts glossary. From the point of view of the textual substance used, the concepts glossary also consists of units. Units are stored and organized in a relational database. Data distribution in the database may be presented in two Entity tables – the Units-table and the Concepts-table. The "Concept-to-Unit" table is to express the relationship between the concepts and the units in the learning material. The occurrence of a precise couple of labels expresses the link "this unit deals with this concept". As all units possess attributes for encoding their disposition in the hierarchical structure and their links with the related concepts, the generation has a semantically structured concept-based occurrence of texts and schemes.

WBLST – a Web-based System for Course Delivery in Sciences and Technologies

WBLST is a Web based system for e-learning, which is an implementation of the described model. Currently it is used in Ecole Polytechnique de l'Universite de Nantes, http://wblst.presidence.univ-nantes.fr/Cobbalt-v2.0/ managing all the support for telecommunications, signals and high-frequencies course inside virtual classes [El Assad et al. (2003), (2005)].

As usually in such systems, each student and professor is given an account, enabling to personalize a convenient mode of learning/teaching. The system provides distant tools for organization, management and supervision of the learning material, including the introduction of concept-to-units links.

One central point of the WBLST organisational system is the virtual class. A class gets together a group of students supervised by a professor. WBLST class provides functionalities for training and communication between the professor and the students.

In general, three different functional devices compose the application software:

- the administrative device, which allows the administrator to manage the users.
- the professors' device, which allows each professor to manage his classes, his class activities and his learning materials.
- the students device, which allows each student to manage its class activities.

The professors' device is used to structure the course and its components, to add, delete or modify the units, the incorporated concepts and their relations (figure 2).

The text in the *section "Content"* (fig. 1) comprises the important for the unit concepts and their definitions. The professor indicates the concepts (keywords and/or key phrases) in each learning unit. That is done in a simple way, by marking the words in the available text. The tool stores all the modifications performed on the server's application. The learning material is imported in WBLST system in HTML format. The files are stored in the database after processing, in order to give to all contents the same look.

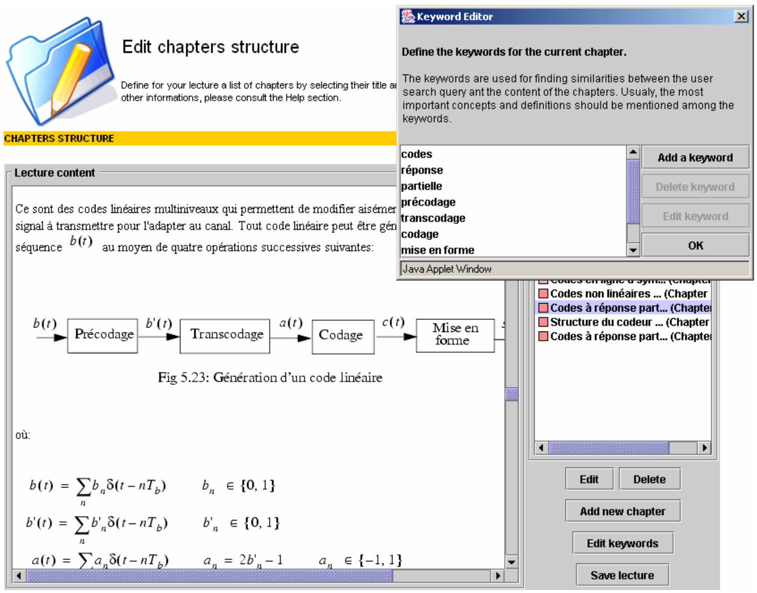

Figure 2. Edit chapters structure (chapter, subs chapter, innerlink, keywords)

The development of an e-course is an extremely time-consuming and heavy task, as has been reported by almost all authors, examining the domain. For example, Ryan et al. (2000) suggest one year's lead time for developing a good web-based course and underline that maintenance by the Course Developer will be needed throughout the life of the course. Mooney and Martin (2003) calculated the preparation of course material task approximately thirty hours for each hour of on-line student time. The approach proposed here cannot eliminate the need for the effort demanded to create the learning material.

Concerning the additional effort that one may suppose is necessary for the concept-based teaching strategy, the developed system includes a simple to use tool, which runs on the Internet and which allows an easy management, structure and maintenance of the course. For example, only two hours is needed to completely structure fifty pages.

The *Exercises Section* offers functionalities for the purposes of tests and exams and includes timing, validation of correct answers, visualization of correct professor solutions or saving partial works.

WBLST provides possibilities to construct an answer-formula by using a virtual keyboard – a special editor, which operates with previously defined graphical objects (figure 3). The technology, used for the implementation, is Macromedia Flash, which has also made it possible to realize the "checking the answer" algorithms by using the incorporated programming language and the XML client-server communication. WBLST uses various technologies currently available. Most of the application is implemented using JSP, CSS, JavaScript. The database server is mySql 4 connected to Apache 2 using Tomcat 5.

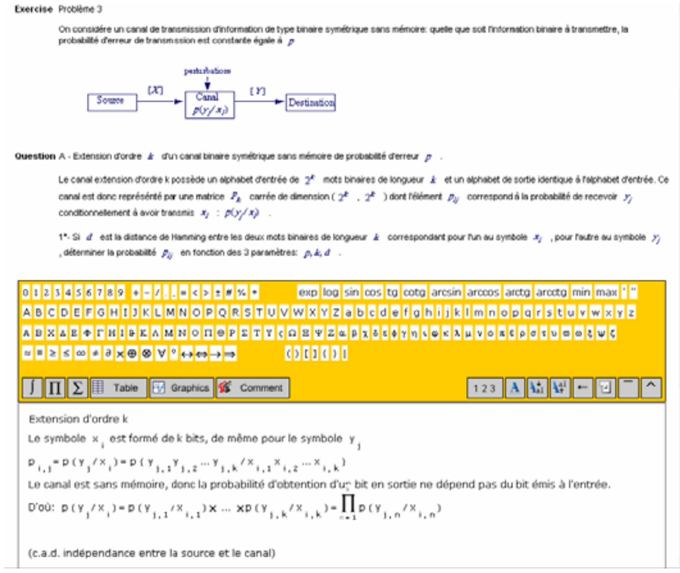

Figure 3. Interface screen of the exercises section (problem and questions)

The device used by the learner provides all the described functionalities merely using the statistical data on the server (databases and statistical folders) and displays the server's generated answer of learning occurrences.

Virtual laboratory is available in the *LabWork Section*. Learner can find the necessary instructions for building simulations, access the instructions and find examples of completed simulations with Simulink under Matlab (figure 4).

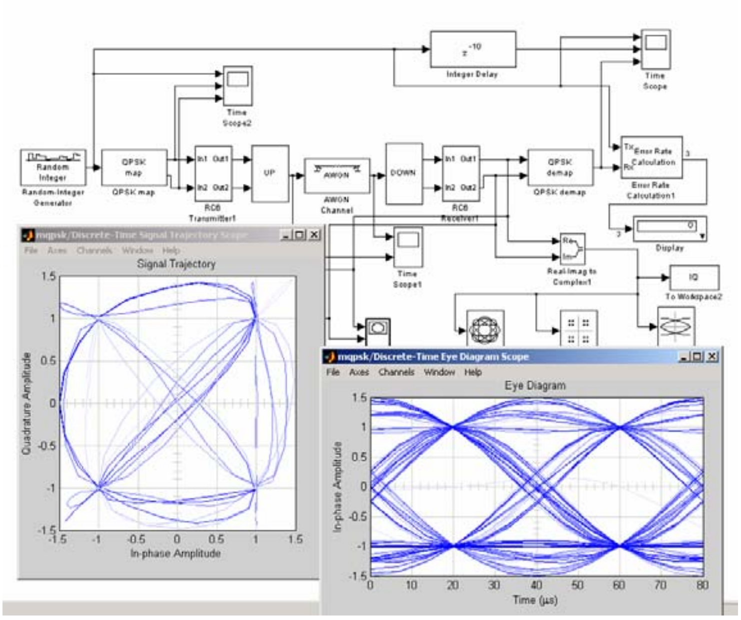

Figure 4. Virtual laboratory interface

Realization of the Learning Assistance

As explained in the previous parts, the learning assistance is provided throughout the organization of the learning material and its relationships with the conceptual glossary. Each concept in the particular domain is stored in the concepts glossary part as a unit containing the "name" of the concept and its formal definition. The "name" of the concept corresponds to the term "keyword" often used in such technologies, but it can also be a term, an entire sentence or a graphical object. By clicking on any of these keywords (e.g: code, coding, etc.), the learner has access to the definition of the corresponding concept, to a hierarchically organized list of "where there is a reference to it", to a list of related concepts and, finally, links to web resources or to a dictionary. Concerning concepts names and definitions, several sources discuss the role of language expression for the conceptualization and suggest that the language processes play their part in helping students to develop abstract content [Rosaen et all (2002), Naeve, A. (2003)].

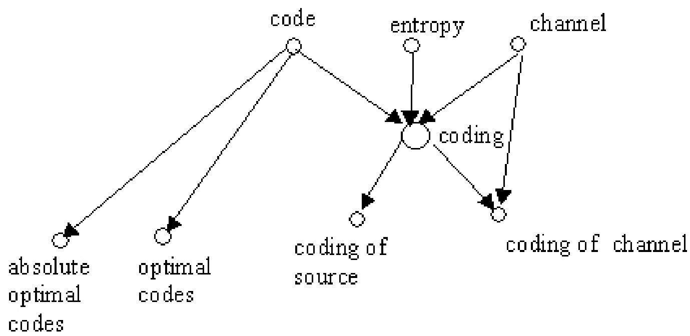

Figure 5. Example of a navigation path through concepts

From the practical point of view, the learner can click on a keyword and, for example, choose to see units from the "content" section, related to the selected concept; to consult the definition; to clarify issues of the related concepts. Consequently, as is illustrated in figure 5, the learner can navigate over the material through a kind of graph of concepts, which covers the learning material, connecting the units in another manner. In this way the navigation becomes flexible between two main modes – following the hierarchy and following the concepts.

The first step of the search gives the learner information about the places in which specific concept is dealt with in the entire learning material. The result is presented on the screen, where the learner can see the titles of volumes (part, chapter, subchapter etc.) within which the concept in question is dealt with, as well as the list of the other concepts, mentioned in the retrieved units together with the concept under consideration.

At the second step of the search the learner has the possibility to clarify the content of a chosen unit by clicking directly on the corresponding title, or to examine concepts, related to the given concept in the context of a unit.

These searching steps provide assistance for the construction of a coherent mental map of the course, corresponding to the concepts edifice and to the semantic links introduced. The aim is to provide a visual support for the creation of a mental scheme of the concepts relations, the size and the ordering of the entire learning material.

Evaluation of WBLST

The WBLST platform has been developed for improving the learning experience in sciences and technologies for the students of "UVPL: Université Virtuelle des Pays de la Loire", by keeping the traditional structure for learning activities, but moving them to the Internet environment using our concept of virtual classes.

During September 2004 until May 2005 twenty professors from different Universities (University of Nantes (France), Politehnica University of Bucharest, Military Technical Academy of Bucharest (Romania), New Bulgarian University of Sofia (Bulgaria), Lebanese University (Lebanon) and different fields of sciences, used the WBLST platform. Fifteen of them have already used WebCT platform. A questionnaire has been administrated to them.

Table 1 Professor's evaluation of the WBLST platform

Question	1	2	3	4	5
1. How easy was it to enter the virtual classrooms (courses, exercises, labworks) without need technical help					100%
2. How helpful was the use of virtual classes to follow distant student activities					100%
3. How easy was the virtual keyboard to enter exercises solution		25%	50%	25%	
4. How relevant was it concerning multimedia aspect		25%	60%	15%	
5. How interesting did you find the WBLST platform?				5%	95%

1 "unacceptable"; 2 "can live with it"; 3 "ok"; 4 "good"; 5 "very good".

The main advantages of the WBLST platform compared with WebCT platform are the properties given by questions 1, 2 and 5. The advantage of WebCT is the multimedia aspect, more developed than in WBLST.

During the same period, one hundred students in the telecommunications field used the system. Their feedback is given in table 2.

Table 2 Student's evaluation of the WBLST platform

Statement	1	2	3	4	5
1. It enhanced my learning experience				10%	90%
2. It was clear and easy to use				15%	85%
3. It increased my freedom degree to learn regarding the space and temporal limitations for traditional classroom					100%
4. It improved my ability for reflective active learning, rather than passive learning			2%	13%	85%

Conclusions and Future Work

The awareness of some specific features of knowledge acquisition has helped to develop an on-line learning system. Aiming to ameliorate the e-learning environment, we have designed and developed the idea of virtual classes, which integrate all the basic real class activities: lectures, exercises and laboratories.

Considering that the degree of knowledge acquisition is one of the main factors for learning efficiency, one major preoccupation for the development of the system was the teaching strategy. The underlying model is based on the assumption that the teaching strategy has to deal with concepts and has to facilitate the overview. The formalization of this idea is realized in terms of database. It allows concept-dependent access to learning occurrences with respect of their semantic consistency.

The efficiency of the learning assistance has been evaluated for telecommunications courses. The results show that the used approach gives a positive effect, confirming the consistency of the underlying model and the effectiveness of the approach. The technological possibility to apply this approach is provided in the developed system, offering tools for content management which are easy to use.

The international team, which has been working on this approach for three years, realized the need for on-line instruction in sciences and technologies right from the start. The extensive need for new and expensive lab material, due to the rapid evolution of technology and the growing number of students, are current problems faced by most technology schools. That has led to further studies concerning e-learning and to the incorporation of a large number of additional technologies and simulation environments. In conclusion, the self-study characteristics of WBLST appear to be better than they would be without the incorporation of the concept-based learning assistance.

The aim of the further development of WBLST is to build up a more generalized virtual keyboard in the scientific domain and to generalize the virtual classes concept to virtual training school.

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