A FRAMEWORK FOR EFFECTIVE AND ADAPTIVE E-LEARNING

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ABSTRACT

Adaptive educational systems adjust the system, by certain user characteristics and preferences, to get the maximum of the user in the learning process. There are existing adaptive systems, used in higher education, which offer courses and guide students by using a well-defined structural approach. However, very few of these systems are paying attention to the students' individual preparations for the exam.

In this paper, we present a framework for effective and adaptive e-learning. A system implementing this framework assumes that the student had previously taken the lectures for a given course, with the main goal to prepare the student for successfully passing the course exam. We discuss the main parts of the framework, and outline plans for successful integration into an existing system for knowledge evaluation.

I. INTRODUCTION

Each student is characterized by different features, learning styles, knowledge and experience [1]. Accordingly, it is a well-established fact that "one on one" learning is amongst the most effective ways of learning [2]. The proof-of-concept of this claim comes with the emergence of Adaptive Hypermedia Systems (AHS) that actually combine the idea of hypermedia space and intelligent tutoring to adapt the system according to specific user properties and learning characteristics [3].

AHS represent a general approach to adaptability in many areas of life. For educational purposes, what we need is an Adaptive Educational Hypermedia (AEH) system that represents one of the first application solutions of AHS [4]. Here, users with different knowledge levels and characteristics are treated differently by the system, allowing the AEH system to guide users through the huge hypermedia space (the space of all available resources) [5].

Most of the existing systems operating within the higher education [6] are only applicable to interact with students during the entire semester, and very few pay attention to the student's preparation for the exam. In this paper, we define research objectives that result in a framework for adaptive e-learning. The main goal we want to achieve is to implement the framework in our existing system for knowledge evaluation, which we refer to as EvaLearn [7], so that it can prepare the student for successfully passing the exam.

From previously entered courses, themes, questions and answers, the professor defines the thematic units upon which the system will check the existing student knowledge. The AEH system then assesses the student's knowledge and, based on the current level of knowledge and on other preferences (such as learning style and prior knowledge), it guides the student through the course learning materials. Finally, on the basis of the prior student interaction (which may have gone through several iterations) and the achieved results on the entire course thematic units, the system issues a recommendation (in a form of a probability estimate) that represents its confidence of whether the student will pass the exam. This allows the effectiveness of the AEHS system to be consistently measured by taking into account the actual student performance obtained on the exams.

This paper is organized as follows. In Section II we describe our existing system used for knowledge evaluation. Section III introduces the standards for development of an AEH system, and outlines the reasons why it is important to follow them. In Section IV we describe our framework for adaptive e-learning, including all its parts and the various techniques and methodologies that need to be followed for its integration into our existing system for knowledge evaluation. Section V concludes the paper and outlines future work plans.

II. EVALEARN: AN EXISTING SYSTEM FOR KNOWLEDGE EVALUATION

In this section, we briefly describe the structure and the design of our existing system for knowledge evaluation called EvaLearn [7].

A. Database design

The data used in the application is of great importance and so it requires an appropriate data structure. This structure is necessary to satisfy the user searching for information from the data, to be suitable for data manipulation by designers and developers, and at the same time to allow for efficient and optimized implementation. To achieve these goals, the application uses the Microsoft SQL Server[1] database management system and the relational model for data storage. Fig.1 shows the EvaLearn database in its 3-rd normal form.

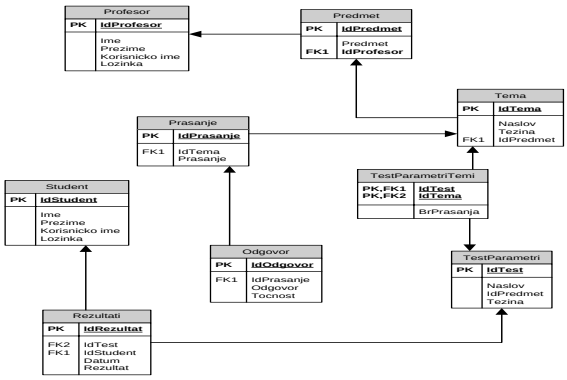

Figure 1. EvaLearn relational database in 3-rd normal form

[1] http://www.microsoft.com/sqlserver/2008/en/us/wp-sql-2008-overview.aspx

B. Modelling the user behaviour

Unified Modeling Language (UML) diagrams are typically used to define the user interaction with the system [8]. In the following we show the two main scenarios which could take place during user interaction with EvaLearn. For example, Fig. 2 and Fig. 3 show two different use cases, one for the student and another for the professor, produced by the exam generation application module.

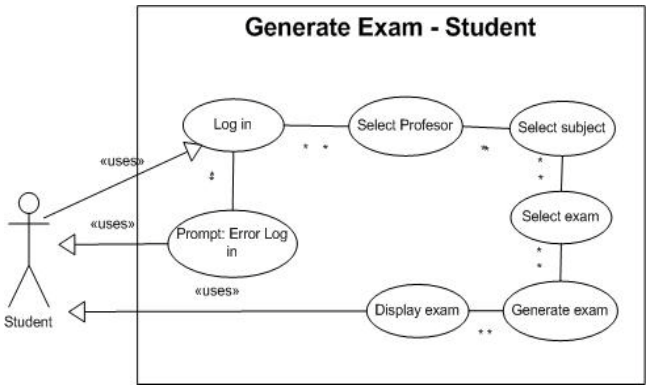

Figure 2. Use case for exam generation: user – student

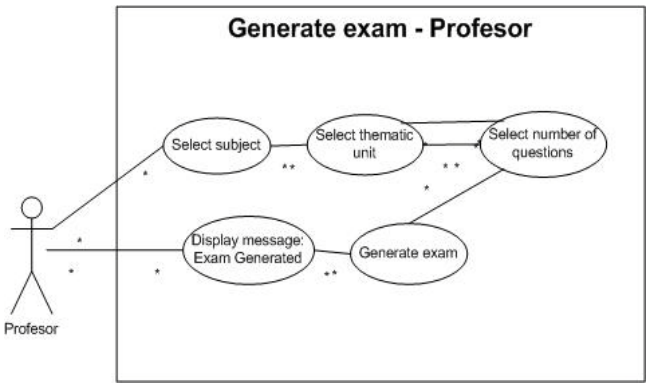

Figure 3. Use case for exam generation: user – professor

C. User interface

We now illustrate the development technologies and modules used by EvaLearn. The application module for generating exam questions creates an extensive database of questions and appropriate answers for individual courses and effective random exam combinations.

The system has two types of users: Student (limited account) and Professor (administrator account).

1) Administrator's pane

Fig.4 shows the Administrator account login page. There are several objects that can be observed, such as currently logged-in user, logout link, password change link, and the main menu that consists of two parts: Add / Delete and Generate Exam. It must be stated that only the courses assigned to the logged-in professor are available for generating template exams. The administrator account allows the professor to generate the exam template with specific exam parameters.

Figure 4. Administrator account login page

2) Student's pane

The Student's pane module is much simpler and has limited privileges. Here the student has the possibility to change the password, but no other administrative activities are allowed (see Fig. 5). The limited account gives the opportunity of taking an exam by choosing from the list of available exam templates. The student therefore chooses an exam template and, according to the specified exam parameters, the system generates questions to which he/she answers, and the results are then inserted into the database.

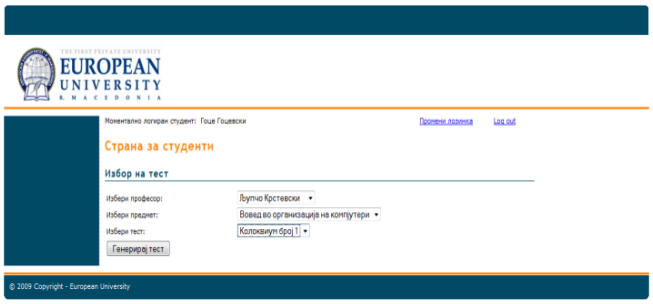

Figure 5. Student's pane

III. AEHS: STANDARDS AND IMPLEMENTATIONS

A key role in building an AEH system is following a strict set of standards [9]. This allows not to get bogged down in the complexity of the system, and to also prevent useless high investments in order to allow easier communication between modules as well as communication between different systems. Protection of high investments mainly involves protection during content specification for adaptive learning, in a sense that in its nonstandard form one could not move into a new environment. Another step further with the standardization is to allow different modules to communicate easily. All this eventually leads to consistent systems that can communicate with each other in a standard way, and thereby expand the set of resources and adaptability.

A. Standard AEHS

A standard AEH system model consists of three main model components [2]: a domain model, a student model and an adaptability model. Figure 6 shows the standard AEH system model, including the way the three components interact among themselves.

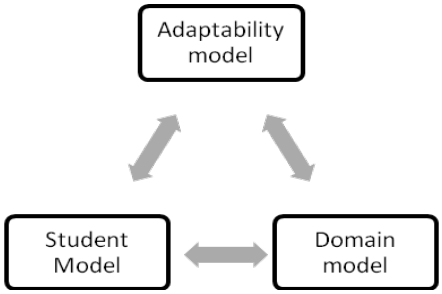

Figure 6. Main components of AEHS

1) Domain model

This model is based on building the concepts of the courses as well as displaying them. Some course concepts include themes, learning goals, expectations, and review of a thematic unit. According to certain logic, all these concepts should be interconnected and be able to form a network allowing for a more diverse student learning.

2) Student model

This model contains information about the students: their previous knowledge, learning styles, interests and experiences with the course [3]. Here, of great importance is the use of the so-called “overwriting method" [4]. The key thing about this model is that the student's knowledge is being assessed for every concept of the domain model. For example, in its simplest form it would be "know=1" or "does not know=0”.

3) Adaptability model

A question posed by Brusilovsky [4] is: "What could be adapted”? He then goes on to define two types of adaptation: adaptive presentation and adaptive navigation support. Adaptive presentation means displaying different content depending on student’s characteristics. Here, as a main feature one typically takes the style of learning. Some students need more explanation, others need little reminder, while there are some that want first to see everything and then begin to learn step by step.

On the other hand, adaptive navigation support means appropriate guidance through materials in the hypermedia space. There are several techniques: direct guidance, sorting, hiding and annotation of links [2].

B. Standard stages of development of AEHS

When creating an AEH system, two main stages with appropriate sub-stages are needed [4]. Figure 7 shows the appropriate stage sequence when developing an AEH system. In the figure, we observe that one must first pass through the *design* phase, and then once this is finished to successfully move to the *authorization* phase.

The design phase begins with designing the structure of the knowledge space where the concepts are defined (course, thematic units, etc.). Then a generic model for the student is designed, which defines the initial characteristics of the student that will influence the adaptivity.

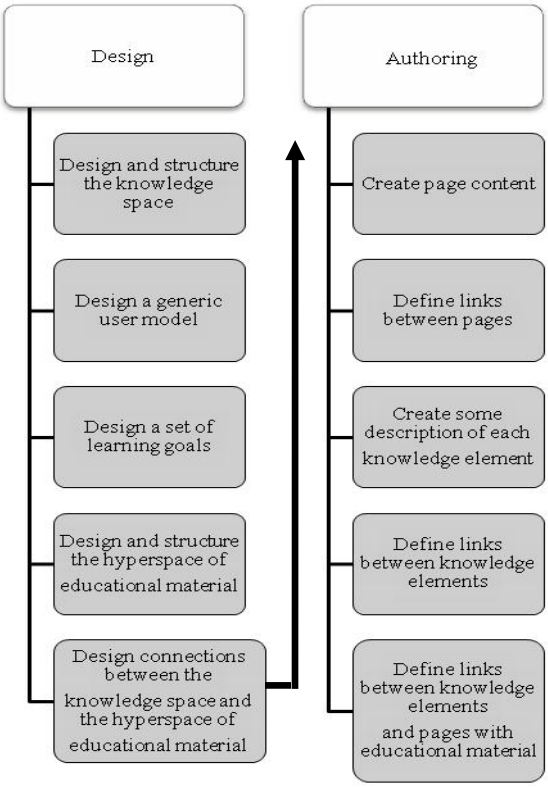

Figure 7. Appropriate stage sequence when developing AEHS

The next three phases involve designing the set of learning goals, structuring the hypermedia space (the space of all the learning materials) and establishing links between the knowledge space and the space of learning materials.

The authorization phase begins with the design of page content that needs to be displayed, following the definition of the links between the structured pages. Description of each learning element is then created, together with links between elements, and finally a linking is established between the elements and the pages in which they are placed.

C. Examples of existing AEHS

Relevant examples and field pioneers in Adaptive Educational Hypermedia systems [1] are:

- ALEA - used for learning programming languages.
- ELM-ART- designed for learning LISP.
- InterBook- system for creation and presentation of electronic books
- ISIS Tutor- amongst the first systems for adaptive e-learning.
- ALE - Creates adaptive courses, monitors progress and based on the results defines the links.

All these systems are based on the standards described earlier and are considered as being leaders in this field.

IV. FRAMEWORK FOR EFFECTIVE AND ADAPTIVE E-LEARNING

In this section, we present our framework for effective and adaptive e-learning. The key research questions that need to be addressed by the framework are as follows.

A. What are the appropriate techniques to determine the student learning style?
B. How can the course thematic units be defined for student evaluation purposes?
C. How can appropriate materials be displayed adaptively, given the previously defined student learning style and evaluation?
D. How can the effectiveness of an AEH system be measured?

In the following we propose various techniques and methodologies that need to be followed in order to integrate the framework into an AEH system.

A. Determination of the student learning style

All people develop specific learning habits that help them benefit on some experiences more than on other. There are different classifications of learning styles [12]. One of the most popular in practice is the classification defined by Honey and Mumford [13], according to whom there are the following four learning styles.

1. *Activists*. Tend to be involved in new experiences. They are clever, with many ideas, but become bored in the process of implementing the ideas. Often, they first act, and then perceive the consequences.
2. *Thinkers*. Want to see the situation from multiple perspectives. They want to collect more data and then make appropriate decisions.
3. *Theorists*. Adapt and monitor complex solutions. They share the problem on smaller parts and go through it step by step.
4. *Pragmatists*. They want to make use of concepts in their work, find the practical aspects and often do not like long discussions.

Honey and Mumford used a questionnaire whose result determines the group style one belongs [13]. The questionnaire[2] consists of 80 questions and there is no time limit for completing it. The accuracy of the results depends on honesty of the respondents. Once the student's preferences are determined, the system will adapt the method for presenting the material and thus raise the learning level. For each of the previously mentioned groups there are different techniques that demonstrate how to teach students (however they are not reviewed in this paper).

B. Flexible way of defining the course thematic units for evaluation purposes

An AEH system implementing this framework assumes that the student previously attended lectures for the course, and so the role of the system would be to prepare the student for successfully passing the exam. The idea is for the professor to create a course, to define the course thematic units, and for each unit to make a sufficient number of questions with supplied answers. Given an exam template (with thematic units and questions) previously created by the professor, the system then randomly generates an exam to the student and thus enables knowledge evaluation. Our existing EvaLearn system is used for this purpose [7].
The results of this evaluation are used later in the process of selecting materials from the hypermedia space.

C. Method for adaptive display of appropriate learning materials

In this part, the adaptivity of the system is expected to reach the highest level. According to the previously defined learning style and the results obtained from the thematic evaluation, the system is expected to make a proper presentation of the necessary materials related to the parts where the student showed the least knowledge.
In order to get flexibility of the display of materials depending on the learning style, the whole hypermedia space will be represented by XML (Extensible Markup Language). XML[3] is a document format that provides distinction between the logical structure of a document from its presentation. In this way, by using techniques such as XSLT[4] or CSS[5] the material can easily be adapted for presentation purposes, following the preferred learning style of the student.

D. Measuring the system effectiveness

Once the student has consulted the learning material, the system should open a session in which the adapted test questions would be defined. However, this time the system needs to emphasize the parts for which, on the basis of previous evaluation, it determined that the student had insufficient knowledge. Once the student successfully passes this questionnaire, the system must decide whether the student's level of knowledge satisfies the (previously determined) threshold for readiness to take the exam. This decision may be based on various mathematical (or probabilistic) models, which should take into account all the prior evaluations.

[2] http://www.incurriculum.org.uk/files/1236697215/honey-and mumford-learning-styles-quiz.pdf

[3] http://www.w3.org/XML/

[4] http://www.w3.org/TR/xslt

[5] http://www.w3.org/CSS

Every system decision that the student is sufficiently ready (eg. over 50%) to take the exam opens the possibility to measure its effectiveness. Namely, if the student passes the upcoming exam, we can say that the system is good and meets the expectations; otherwise, the system will have to undergo certain improvements and modifications.

If the system determines that the student does not satisfy the threshold of knowledge, it should present another learning session for the student. The whole adaptive learning process is presented in Fig. 8.

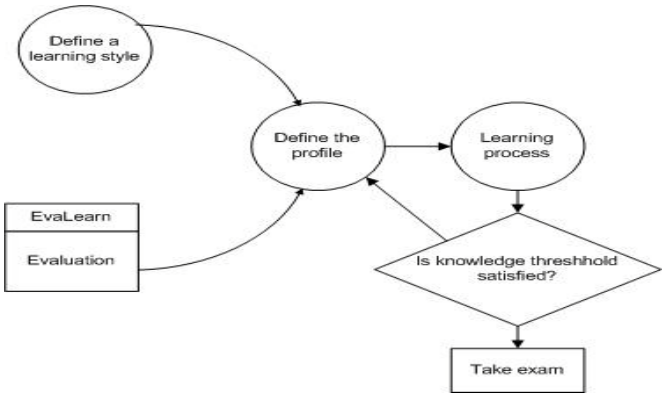

Figure 8. AEHS learning process

V. CONCLUDING REMARKS

Students are characterized by different features, learning styles and prior knowledge. Adaptive Educational Hypermedia (AEH) systems try to take into account these preferences and teach the student accordingly. In this way, the systems adapt and generate profiles according to the student needs in order to extract the maximum learning outcome.

When developing an AEH system, it is of particular importance to follow the standards related to the core components that will guide the development process. The three main components of a standard AEH system are domain model, student model and adaptability model. On the other hand, there are two main stages in the process of building the system, namely design and authorization. Both phases contain sub-phases that also need to be followed very carefully.

Most of the existing systems operating within the higher education are only applicable to interact with students during the entire semester and very few pay attention to the student's preparation for the exam. We have presented a framework for adaptive e-learning that is focused on the latter activity and that can easily be implemented in any existing AEH system. The framework consists of four parts: a part to determine the student learning style, a part that allows for a flexible way of defining the course thematic units (mainly for knowledge evaluation purposes), a part that defines a method for adaptive display of appropriate learning materials, and a final part that allows for the effectiveness of the adaptive e-learning system to be consistently measured.

In the future, we plan to integrate the proposed framework into our existing EvaLearn system that is currently used for student knowledge evaluation. This, we believe, would allow us to create a comprehensive experimental environment where many parameters of this framework could be thoroughly tested and systematically improved.

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