Adaptive E-Learning System in Secondary Education

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***Abstract*—In this paper we describe an adaptive web application E-school, where students can adjust some features according to their preferences and learning style. This e-learning environment enables monitoring students progress, total time students have spent in the system, their activity on the forums, the overall achievements in lessons learned, tests performed and solutions to given projects. Personalized assistance that teacher provides in a traditional classroom is not easy to implement. Students have regular contact with teachers using e-mail tools and conversation, so teacher get mentoring role for each student. The results of exploitation of the e-learning system show positive impact in acquiring the material and improvement of student's achievements.**

***Index Terms*—Educational Hypermedia, E-learning, Mentoring activities, Self-improvement**

I. INTRODUCTION

The data and information play very important role in our information society. Knowledge and learning are becoming more appreciated. Also, new requirements change and chalenge the educational systems to use better and more efficient methods of learning. The implementation of new developments in education offers chalenges and opportunities such as distance learning, lifelong learning and e-learning.

One area of particular interest in adaptive educational systems is hypermedia. By means of incorporating techniques for intelligent tutoring in traditional hypermedia, learning systems are able to identify individual users needs and consequently to adapt the learning curriculum. Such systems are also able to adapt the content and presentation to each individual user, as well as to provide dynamic support for navigation through hypermedia material. Ability for adaptation to the needs of individual user can significantly improve the teaching process, as has been shown that the best method of teaching is individualized tutoring [1].

There are thousands of web-based courses and other educational applications on the Internet, but most of them are static hypertext pages. An important research goal is the development of web-based educational applications that can offer adaptability and intelligence. These features are crucial for web-based applications because the distance learning users usually work in their own way. It is easy to get intelligent and personalized assistance in a traditional classroom, but it is not just a trivial problem in e-learning applications. Furthermore, adaptability is important for web-based courses, as they should be used by a much wider range of students. Web courses are designed for a specific class of users and may not suit other users. Ever since the very beginnings of the Internet, many research teams have implemented different types of adaptive and intelligent systems for distance Web-based education.

The first part of this paper is an overview of the research in this area. Then we describe an application that implements adaptive learning system for secondary education. At the end we discuss the results that are obtained using this learning environment.

II. INTELLIGENT TUTORS IN WEB-BASED EDUCATION

Intelligent tutors are one of the research areas in developing adaptive and intelligent education systems (AIES) [5]. The intelligent tutoring systems (ITS) have to integrate knowledge from a given domain, student's knowledge and strategies that support flexible individualized learning. Brusilovsky identified three characteristics of the technologies that use intelligent tutors: sequencing the learning materials, intelligent analysis of student's solutions and support for interactive problem solving. All these technologies have been implemented in different learning systems with intelligent tutors. The first Web-based learning systems were developed in 1995-1996 [3, 4,8,9].

The goal of sequencing the curriculum (also known as technology of planning the teaching) is to provide the best sequence of lessons for the student and determine the sequence of learning tasks (examples, questions, problems, etc.). In other words, this technology helps students to find "optimal path" for learning the material. A classic example is the system BIP [2]. There are two fundamentally different types of sequencing: active and passive. Active sequencing involves the learning goal (a subset of the domain concepts or topics to master). Systems with active sequencing can build the best individual path to achieve the goal. Passive sequencing is a reactive technology and does not require a goal of learning. It begins when the user is unable to solve the problem or to accurately answer the question. The goal of passive sequencing is to offer the user a subset of the available learning materials, which can supplement the lack in knowledge. Systems with active sequencing can be divided to fixed systems and systems with adaptive learning goal. Most of the existing systems support the fixed goal of learning - a series of concepts from a particular domain. There are several systems with adaptive learning goal in order to enable the teacher or student to choose a subset from the entire range of concepts, like current learning goal. In most ITS sequencing systems, it is possible to distinguish two levels of sequencing: high and low. The high level of sequencing determines the next learning sub goals: next concepts, a set of concepts, topics, or lessons to learn. The low level of se-

quencing or sequence knowledge determines the next learning task (problem, example, test) within the existing sub goal. High and low levels of sequencing are performed by different mechanisms. In many ITS systems only one of these two mechanisms is intelligent. For example: the lesson is chosen by the student while learning tasks within the lessons are selected adaptively by the system. Some systems can only manipulate the order of the tasks of a particular kind: usually problems or questions. In this case it could be called a sequencing problem or issue.

Sequencing is currently the most popular technology in web-based AIES. Almost all types of sequencing mentioned above are already implemented in the systems. Active sequencing is the dominant type of sequencing. Only a few systems (InterBook, PAT-InterBook, CALAT, VC Prolog Tutor, and Remedial Multimedia System) can perform passive auxiliary sequencing. Among active systems for sequencing, only a small number of systems such as ELM-ART-II, AST, ADI, ART-Web, ACE, KBS-Hyperbook and ILESA are able to intelligently perform high and low level sequencing. Others, such as Manic, leave a choice of activities within a certain topic to the user. Conversely, some systems such as Medtec, leave the choice of the topic to the user, but can generate an adaptive sequence of problems within the topic. Most of the systems support sequencing with fixed learning goal (equal for the entire course). Only a few systems support adaptive learning goals that permit the teacher (as in DCG) or student (as in InterBook and KBS Hyperbook) to choose a particular goal. The student can choose a goal as a subset of the domain concepts (InterBook) or project (KBS Hyperbook).

Active sequencing in most of the systems is driven by the actual knowledge of students (the difference between student's knowledge and the main goal). Several systems and projects, however, experiment with using preferences of students for the type and media of the available teaching material to guide the sequencing of tasks within a topic [6, 7, 11]. Two interesting cases of sequencing can be found in DCG and SIETTE systems. DCG can perform advanced sequencing of educational materials adapted for the purpose of learning. However, sequencing is done before students begin to work with the system, producing a static web-based course. SIETTE [10] is an example of an adaptive web-based testing system. The only learning materials are questions and the only thing one can do is to generate adaptive series of questions to assess knowledge of the student. Systems as SIETTE are incomplete in nature and should be used as components in distributed Web-based AIES.

Although sequencing of the program can be considered as the oldest ITS technology for about 20 years it became obsolete compared to other technologies. The emphasis on research in ITS was focused on technologies to support problem-solving. Support for problem solving was considered as the main task of the ITS, while separation and sequencing of educational material should be done outside of the system (usually by the teacher). Normally, almost no one ITS does include educational material (except the set of problems). The situation with web-based AIES is very different. In the context of web-based education, what is needed is a certain amount of educational material (usually structured as a hyperspace). In that curse technology for sequencing the program becomes very important to lead the student through the hyperspace of available information. Using the Internet, it is easy to implement this technology: the whole knowledge can be located on the server and all the sequencing can be done by CGI (Computer-Generated Imagery) - script. It is a fact that the CGI is not only among the oldest, but also one of the most popular technologies of web-based AIES.

III. E-SCHOOL APPLICATION

A. General Characteristics

E-school (Fig. 1) is a web application, which includes adaptive characteristics, i.e. the student is able to adapt some features of the system. The students on their own can monitor their progress, follow the lessons posted by teachers, perform tests or set of exercises, give solution to projects, participate in forums and questionnaires, and completely fulfill the requirements for the courses. E-school system contains a lot of elements of the previously mentioned Web-based applications. Teacher gives directions for using the system. Students have regular contact with teachers via e-mail tools and conversation, so the teacher gets a mentoring role for each student. The teacher can monitor the total time that student spent in the system, the overall achievements in lessons learned, tests and projects.

The system provides an assessment of the achieved results (Fig. 2).

The student can use the system in the classroom, if necessary, but the main purpose is to use it at home following own needs and preferences (Fig. 3).

The teacher can set limitations, like not going to the next topic if the previous is not learned, in situations where some topic is dependent on another. For example, if the student has not learned Open Writer, he/she cannot learn Calc.

Figure 1. The main page of the application

Име: **3. Барање податоци на интернет**
Категорија: **Прва година**
Корисници: **155 (Ученик: 154, Професор: 1)**

Корисник	Севкупен напредок	Резултат од тестови	Резултат од проекти
Barbutov T. (barbutovtome)	100.00%	64.06% (2/4)	75.00% (1/1)
Sharlamanova B. (BlagicaS)	0.00%	65.63% (1/4)	0.00% (0/1)
Божинова С. (bozinova)	100.00%	34.38% (1/4)	70.00% (1/1)
Corevski D. (dimitar.corevski	0.00%	65.63% (1/4)	75.00% (1/1)
Gligorova M. (GligorovaM)	100.00%	50.00% (1/4)	0.00% (0/1)
Коцева Г. (glorija.koceva)	100.00%	81.78% (2/4)	90.00% (1/1)
Vasilev G. (gorgi.vasilev)	100.00%	75.00% (1/4)	0.00% (0/1)

Figure 2. Assessment of the results achieved by the student

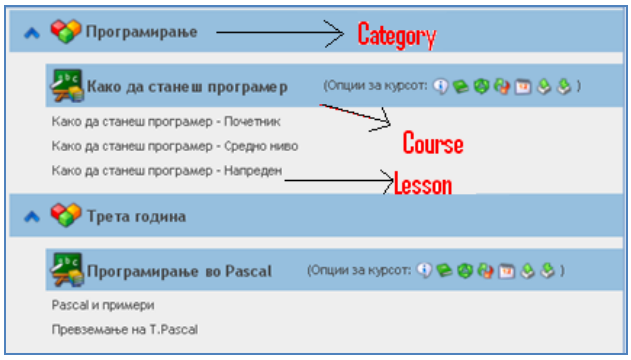


Figure 3. Adaptive representation - lessons that have to be learned by a particular student

While reading a lesson, the student has a choice of moving to next or previous one, if he/she wants to compare any information or to be reminded of something. Once he/she passes the lesson, the system marks the lesson as learned and increases the cumulative percentage of his/her knowledge. After the lesson is marked as learned, the student can go to other lessons, courses or can use other tools.

The learning materials include hyperlinks to additional literature, visual and auditory tutorials, which can attract the attention of the students and demonstrate the practical implementation of some program or tool. Best projects made by students (in P. Point, Movie Maker, etc.) are part of the tutorials. This further motivates students to develop better projects, because they are directly involved in the learning process and can help each other.

The teacher announces new projects about upcoming activities: dates when tests are performed, deadlines for the projects, etc. Hence, students have in advance clear working plan. Through the forums they have opportunity for discussions, working in groups and for communication with the teacher to successfully complete the assignments. Students can send their projects through the system and see the evaluation and comments made by the teacher. The system enables organizing a competition for the best group project which can be evaluated by the students.

Like most of the web-based systems, there are 3 basic types of users: administrator, professor and students. It is possible to create other types of users which are based on the 3 types mentioned earlier, but have different features defined by the course administrator. For example, we defined type: assistant professor. Certain data are available for the assistant, while others may be hidden from him. But also, one user can be a student and a tutor to another one (it means he acts as a student, but there are more options available to him, unlike other students). Student in the role of mentor may oversee the work of another student, to set tasks and to assist in learning the material in the same way as the teacher does. However, the teacher decides what and how will be available to the mentor-student. The best solution is if one of the professors has the administrator's role, in order to coordinate the rest of his colleagues.

UML diagram in Fig. 4 shows the interaction of all three types of users with the system. The administrator creates profiles, courses, categories and sets parameters for the system. The professor defines lessons, tutorials, assignments, test questions that are stored in the database. The student through adaptive presentation and navigation

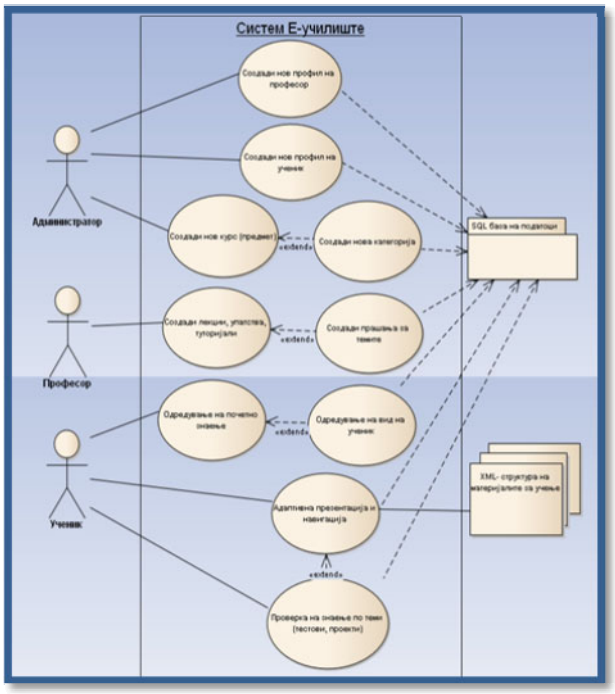


Figure 4. UML diagram that shows the interaction of the users with the e-learning system

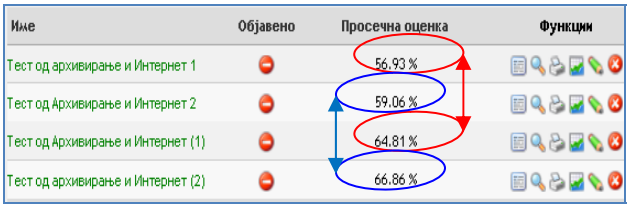


Figure 5. Average grade after performing second test with different questions on the same material

follows lessons, and then solves given tests and tasks. Student's parameters are stored in the server's database. E-school allows interactive communication with the users and monitors their learning progress.

B. Test Tool

The student can make a test, but it will be considered as valid only if he/she has previously learned 100% of the planned material, i.e. after he/she passes all the lessons in the course. Final test is performed under special conditions (in classroom, with limited time and mixed order of questions).

The teacher can repeat the test in order to compare the scores or to take as valid the average score from both tests. Figure 5 shows the improvement of the results when the test is repeated with different questions.

Percentages circled with the same color show improvement in the results of the same group consisting of 70 students. Students can find the answers in the lessons and can perform the test again.

The teacher can monitor the overall work of the student and the total duration of the student's interaction with the system. The system produces statistical data for the test and average grade for it. So the teacher can see the weaknesses in student's knowledge and correct them as necessary. One of the main problems is the choice of questions

for the test. Whether it has to be static or to allow change of the questions? The system has the ability to mix the questions in order to prevent whispering and consultation during the test. In addition, system can allow going back to unanswered questions. The fact that time is measured for each test question prevents manipulations during the test.

When most of the lessons are covered, the best practice is to give about 50-100 questions for each topic. After learning all the lessons a testing period is set by the teacher, when the students will be able to check their knowledge. Several types of questions can be created: multiple choice, questions with short answers, true / false, questions for comparisons etc. Additionally, the teacher can put weight factor to each question.

Thematic test consists of 15 questions. Teachers can create a number of tests and mix the questions for different groups of students. They decide when and whether the tests will be available for students (a short period of several hours), the tests remain inaccessible throughout the year. This enables updating the sets of questions, rather than repeating the same questions every year. In this way, teachers can easily create a final annual test (corresponding to external verification) from a large database of questions. Assessment obtained on this test would be an important element in establishing the annual grade of the student. The main goal of this research would be to achieve a minimum deviation on the scores of final test and the external test and general improvement of student's achievements.

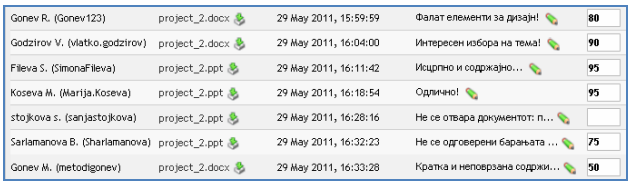
C. *Work On Projects In Groups*

E-school system enables individual or group project set by the teacher, in order to check student's creativity in solving a given task. Once the project is announced, all the users of the course have the obligation to send the solution of the project. The project consists of a description, explanation, requirements, deadline and criteria for the evaluation. Depending on the subject, the project can be individual or team work. After the deadline, the project becomes inactive and the solutions will not be accepted. Thus, students are taught to be accurate and responsible for its liabilities, which lacks at most of them. After the deadline, the teacher evaluates the project and the student can see the project rating in points and comment, based on the criteria established earlier (fig. 6).

This assessment is a part of the tasks required to accomplish the course, and these points are taken into account when evaluating the final grade for the course.

The intention of working in groups is to encourage interaction among students and to increase their creativity by providing solutions to a set of problems.

The interactions can be achieved by "pairing" students or determining the potential collaborators. The group will solve the problem when each sub-problem is solved by one or more members of the group. E-school system provides assistance in the way that students can link with partners-helpers. Partners-helpers are students assigned to that group from senior classes that can assist the group. Also, once the task is defined to be solved by the group, individual students can be grouped according to their individual roles, assigned within the team. It is necessary to decide which features the students can use when creating the structure of the group. This assignment has yet another



Gonev R. (Gonev123)	project_2.docx	29 May 2011, 15:59:59	Фалат елементи за дизајн!	80
Godzirov V. (vlatko.godzirov)	project_2.docx	29 May 2011, 16:04:00	Интересен избора на тема!	90
Fileva S. (SimonaFileva)	project_2.ppt	29 May 2011, 16:11:42	Исцрпно и содржајно...	95
Koseva M. (Marija.Koseva)	project_2.ppt	29 May 2011, 16:18:54	Одлично!	95
stojkova s. (sanjastojkova)	project_2.ppt	29 May 2011, 16:28:16	Не се отвара документот: п...	
Sarlamanova B. (Sharlamanova)	project_2.ppt	29 May 2011, 16:32:23	Не се одговорени барањата ...	75
Gonev M. (metodigonev)	project_2.docx	29 May 2011, 16:33:28	Кратка и неповрзана содржи...	50

Figure 6. Project rating and feedback to the students

benefit: students become more familiar to the teamwork, which is an important feature for any professional. Thus, each student has his own role and responsibilities, in order to solve a practical problem. Students who do not collaborate with the rest of the team, do not contribute to the project and get poor evaluation.

D. *Communication Between The Users*

All users of the system have several options for communication and discussion, such as forum, e-mail, chat and calendar. The ultimate goal is to achieve the best organization, especially between the students, in order to get the best results of reading, taking tests, solving problems and exercises. The system has characteristics of a tutor, but still the professor is the one who provides personalized help to his students. Nowadays, statistics shows that students get impatient when not receiving the information they need from their teachers, and that they even use social networks to get it faster. In the E-school system, teacher creates groups (classes or other formations) and is able to send emails to the whole group at once, to publish news, to remind the group for important dates, to discuss certain topics. But still, communication remains private, without monitoring and feedback "from outside".

IV. EXPLOITATION OF THE SYSTEM

The E-school application in practice confirms the usefulness of utilizing an adaptive e-learning system. We also obtained an empirical evidence of how students progressed by using the adaptive e-school system compared to those who did not use it at all. E-school system was tested with students of the first and the second year of high school. During the last quarter (March-June) students got the obligation to use the system and to complete the tasks for the subjects they attended. The study encompassed 135 first-year and 150 second-year students.

We analyzed the class average scores before and after using the application E-school (Fig. 7). In general, in each class there is improvement of the average scores. Improvement is higher in those classes that have a greater number of registered users in the system. We expect this improvement to be even more obvious when students will become more familiar with the system.

Students spend a lot of time on-line, so it came out that they prefer to organize their time and commitments using computers. We expect that students will get used to work in groups and also to meet the individual obligations set by the teacher.

The estimation of the final grade is based on several elements. The system itself gives a grade for a particular student, depending on his/her results achieved using the system (tests, projects, progress in lessons).

Figure 7. Average scores of classes before and after using the E-school application

Thus, the e-school system eliminates any subjectivity in the assessment, which all educational reforms tend to achieve.

650 students in total are registered at this moment in the e-learning system. It is noticeable that students habituate to check for announcements, to perform pre-tests and to check their achievements. Other groups of students are included in the e-learning system, as for example, students who want to gain additional knowledge in programming languages and talented students who are going to attend the state contest in programming. E-school effectively supports these categories of learners.

In order to evaluate the effectiveness of the system E-school students were asked to answer 20 questions about their experience working with the e-learning system. Part of the results is shown in Table I. It turned out that students want to have a record of their own achievements and believe that this method of testing is objective. They want to have all the information on-line, because most of the time they spend working on the computer. Above 85% of the students have positive experience using the e-learning system. From the survey, we can conclude that every aspect of the system was evaluated as positive, except for the limited time for answering the questions during the tests.

The survey was conducted anonymously and one third of randomly chosen students were asked to participate in the evaluation.

The e-learning system E-school is accessible at: http://www.e-uciliste.info

V. CONCLUSION

Usually, every innovation and change in educational systems produces resistance, but surprisingly the e-learning system was accepted with great interest by the students. As previously analyzed, it certainly is due to the fact that nowadays students communicate on-line and have fun looking for data on the Internet. So why not learn on-line instead of learning from books?

What characteristics contribute to the adaptivity of E-school system? Apart from selecting the lessons, improving the results with self-testing, assistance in problem solving, adaptive navigation and availability of additional learning resources, students adjust the system according to their preferences, learning styles and learning rate. Students become more responsible in performing their obligations, learn how to work in a team, giving the most of theirself, to be succsesfull. Of course, there was a small number of students who were not registered at the system, or didn't show any interest to use it.

The results showed a positive impact of the learning system on the achievements of the students. Students that used the system were on average 26% more successful than the small number of students that were not registered.

During the process of interaction the system builds a model of each individual user that consists of learned lessons and test results.

The ability of the system to adapt to individual user preferences, learning style and level od knowledge leads to achievement of better learning results.

The new trends identified in the learning systems lead to a new paradigm, where the students are transformed from passive listeners and recipients of information to active participants. To achieve this, the whole process of learning is adjusted to the student, his knowledge, abilities and preferences. Instead of insisting on the ability to merely reproduce facts, the goal is to have the student as

TABLE I.
STATISTICS (IN %) OF STUDENT'S EVALUATION OF THE SYSTEM

Q.No.	Question	Fully disagree	Agree at small %	Agree	Agree at great %	Fully agree
Q1.	I am registered user at E-school	3	0	0	0	97
Q2.	This way of learning can help me a lot	3	12	21	16	48
Q3.	The way of taking tests is objective	8	8	12	24	48
Q4.	I don't like the time limit during test	12	9	8	13	58
Q5.	I like pre-tests so I can prepare better	3	3	7	11	76
Q6.	I can Immediately get the result of the test	1	2	8	12	77
Q7.	I can improve the result by taking the test again	3	0	6	14	77
Q8.	I can track the progress in learning (measured in %)	4	9	10	18	59
Q9.	I like that I can communicate to the professor and my class mates	3	8	8	24	57
Q10.	I like that I can send the projects and get the result on-line	1	4	11	22	61
Q11.	I prefer working with e-school, rather than traditional classroom work	10	8	14	9	59
Q12.	I would like next year to use E-school, too	8	3	8	21	60

active researcher, analyst and problem solver, with developed analytical and creative attitude towards learning and capable for self-learning. It is generally accepted that within the process of reorganization of the educational system, information and communication technologies have a crucial role. So, e-learning systems that implement electronic tutors, collaborative learning in real time, like chat, forum, video/audio conferences and virtual classrooms are more appreciated by the contemporary students.

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