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Using eTesting methods in CS education

Goce S. Armenski¹, Marjan Gusev²

Abstract - This paper reports results from a study on using electronic testing tool for assessment of student knowledge in few university courses for CS education. The study was basically concerned with the effectiveness of using electronic testing tool for assessment purposes. The effectiveness was analyzed through cost savings and improvement of quality of the assessment process, viewed from both perspectives: the teacher perspective, and the student perspective. Data gathering took place over six semesters after which questionnaire was completed by the students through which their experiences and reactions were evaluated. Analysis of data about effectiveness viewed from teachers perspective was gathered through informal interviews with faculty members that administer and create computer-based tests.

Keywords - eTesting, eLearning, web-based assessment.

I. INTRODUCTION

The characteristics of the society in which we live, where knowledge and the ways of its use are the most important in everyday life, brings new challenges for the higher education. Increased number of students and increased use of computer technology in the process of learning, are forcing higher education institutions for its use in the process of assessment. Maybe one of the most important reasons for using technology in the assessment process is the fact that it is already becoming a tool which is very often used in learning and working. The use of different medium in assessment than the one which students use for learning can bring improper assessment results [2] [3].

Computer assisted assessment cover any use of computers in the process of assessing the knowledge, skills and abilities of individuals. The term encompasses the use of computers to deliver, mark and analyze assignments or examinations. It also includes the collation and analysis of data gathered from optical mark readers (OMRs) [4]. Computer based testing is any use of computers in testing, taking quizzes and other assignments [1]. The extensive growth of WWW allows assessment process in which the access to the testing system can be made with any electronic devices (mobile or static) which has access to Internet. This fact brings us to electronic testing, term which encompasses use of electronic devices in the testing process [1]. The system which allows access with different electronic devices is called electronic testing system.

These systems include various methods for database management and artificial intelligence to support decision-making process for generation of testing material. All these activities are realized through WEB based Internet technologies.

Large number of authors points out that the extensive growth of the information technology scientifically increases the use of computer-based testing as effective tool for knowledge assessment of a large group of students. At the same time, there are many studies which are focused on the implementation of the computer-based testing, and the results of that implementation. Usually the studies analyze use of existing software packages in high schools [5] and universities [6]. According to the results from these researches, the use of computers and web technologies in the assessment process, compared to the traditional way of assessment, are improving student achievements [6]. As Bocij and Greasley conclude [6], with using computer-based testing the effectiveness is increased and the time for test completion is decreased, allowing more time for thinking and solving the problems.

The advantages of computer-based testing can be viewed not only from education perspective, but also from business perspective. The achievements in this area can be categorized in three categories [6]:

- business dimension, where the effectiveness and savings are dominant;
- training aspects, where the most important is the creation, administration and management of feedback
- technical dimension, where the most important are integration, security, extensibility and usefulness

This paper focuses on a study to assess the effectiveness of the implementation of the system for computer-based testing at the PMF Institute of Informatics. The global goal is to identify the influence which the use of a system like this have on students and teachers, and the main goal was to see if the use of computer-based testing is more effective and more objective than traditional one.

Since we are discussing the effectiveness of the system which is implemented, and its influence in the assessment process, we must define what we will understand under the term effectiveness, because this term is defined differently depending on different points of view. According to Oxford, Cambridge and RSA Examinations, one of three main commissions for assessment in United Kingdom, few criteria exist which every software for computer-based assessment should achieve in order to be assumed as effective. The main criteria's are: cost reduction and quality improvement of the assessment process.

The quality improvement can be analyzed from two aspects, from teachers point of view and from students point of view.

¹Goce S. Armenski is with the Faculty of Natural Sciences and Mathematics - Institute of Informatics, Skopje, R. Macedonia, E-mail: armenski@ii.edu.mk

²Marjan Gusev is with the Faculty of Natural Sciences and Mathematics - Institute of Informatics, Skopje, R. Macedonia, E-mail: marjan@ii.edu.mk

II. eTEST SOFTWARE DESCRIPTION

In this section we will give brief overview of the software we are using for assessment of student knowledge and whose effectiveness we are exploring.

The system we have implemented at the PMF Institute of Informatics is realized as WEB application with three layer architecture. Main reason to realize this system not as classic client server application is the characteristic of Web applications to be installed on one computer and used on any computer on Internet through common web browser. This is very convenient for students since they are not obliged to come at university to use the system, and can efficiently use e-business paradigm anytime, anywhere. A good survey of Internet as Business Infrastructure and also for e-Testing system can be found in [7].

The three layered architecture of the system is shown on Fig. 1, realized by separate database layer, application layer for basic system modules and user interface layer.

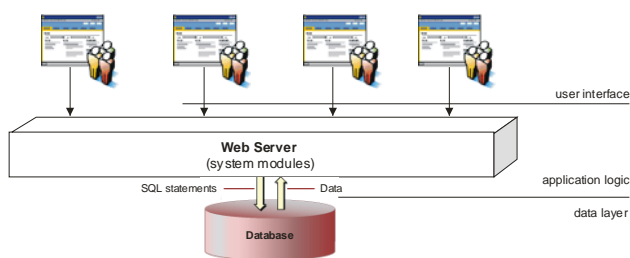


Fig. 1. Three layered architecture of the system

The basic structure of the system consists of courses which material is divided in lectures. A tree like organization of lectures is implemented. Each lecture consists of smaller parts and each part consists of different sets and finally of learning objectives, as shown in Fig.2 [1]. The course material in the lesson is divided in at least three parts (in Fig.2 marked as A, B and C). For each part there are at least 4 sets of questions. Each set of questions consists of at least 5 questions. At least one of these questions is hidden and is intended for final test exam, not for testing purposes. The remaining questions are candidates for online testing.

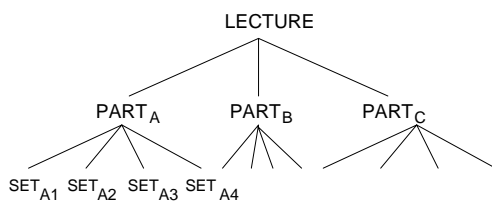


Fig. 2. Tree like organization of the lectures

All modules which system consists of, are realized with complete implemented windows concepts supporting multimedia capabilities. The data entry tool is realized to allow easier definition of questions in all segments in two versions: as standard data entry dialog and as a possibility of bulk entry from a file. In the bulk entry case, the file is xml content, where not only the questions and answers are defined, but also the headings and their order in the tree like organization.

The database of questions and answers are kernel of the system. The way the questions are set and the order they are

presented defines the test creation algorithm [8]. These algorithms differ in presentation and delivery media and according to those differences we can categorize them in 5 categories. The model we have implemented in the system we have designed, are dynamic linear tests, nonadaptive to the student knowledge. Each test is generated randomly according to predefined conditions.

The tool for question database editing and organization enables the lecturer or the tutor to organize the tree structure, to establish new areas, to rename their names, to move the questions from one to another area, to delete a question or an area, to define sub and super areas, to change question or answer options body text. Also the test administrator is allowed to enable or disable each question for the process of learning.

Test and exam definition tool defines a strategy. A strategy is a selection of question sets or parts that form the actual test. Test administrators can efficiently use the report tool to see the student progress, its tests and check his knowledge or absence of specific skills. The lecturers are allowed to see each student log file of activities and the test itself.

The self testing procedure allows the students to get familiar not only with the multimedia interactive Internet WEB technology to realize the test, but to get familiar with the course material and concepts to be learned. These sessions can be carried in informal atmosphere and students are allowed to talk freely or refer to notes. The self-testing procedure is a realization of web-based testing that offers 24-hour access to testing with the e-Business concept anytime, anywhere. It also allows them immediate scoring, and a more limited need for test administrators, leading to convenient, cost-effective and efficient testing.

A lot of the questions available for self-testing are same as the exam questions. However, there are still questions in the database allowed only for the exam. Also a lot of modifications of the original questions for self-testing were realized. Thus, even if a question appears to be similar to a question the student has already seen, it may in fact be a different question and may also have a different correct answer, since the order of the given answer options was random generated. This concept actually motivated the student to learn the concepts associating the questions and correct answers instead of memorization the line number of the correct answer for a given question. Another method to prevent from cheating and recognition can be realized if the same answer options are given for different questions, that will confuse the student if he tries to cheat and recognize the pair of question and answer, not by learning the concept, but trying to memorize.

Security is very important issue and encryption is integrated in the system with modules to establish authentication, authorization, archiving, privacy, integrity, availability, and unreputation.

Along with the security system there are many methods that prevent cheating, like time constraints, preventing memorization with random generation of questions and random position of the options to be answered, negative scoring for wrong answers, etc.

III. DATA GATHERING

The system for electronic testing eTest is implemented at the PMF Institute of Informatics in 2001 and has been used for summative and formative assessments usually when student number exceeds 100, often going up to 150. In order to assess more students at the same time, the summative assessments are carried out in 3 computer labs at the same time with exact time schedule. During the assessment process, besides the security functionalities implemented in the software, other security steps are taken necessary to avoid the traditional forms of cheating. The summative assessments are supervised by Institute staff.

The analyze of the results from its implementation and its use will be held from the experience we have using the system at the Institute of Informatics during these 6 semesters of its use. In that period, the system was used for summative assessments in 12 courses, 327 assessments were held, and 5291 tests were generated during these assessments.

IV. EFFECTIVENESS OF THE ETESTING SYSTEM

A. Cost reduction

One of the main results that should be achieved with the automation of the assessment process should be cost reduction, as is usually case with all automation procedures. In some cases, cost reduction is not possible for short period, especially when in the automation process software development and maintenance is needed, and training of those which will use the software must be obtained.

With the implementation of the system for electronic testing eTest, existing way of receiving assignments and questions on paper is changed with possibility for electronic delivery of questions and answers. With this, the use of paper is significantly reduced, and all printing resources for assessment preparation are eliminated. But, the use of systems like this one may cause lots of technical problems, which brings on the need for constant technical personnel, which is increasing the costs for its implementation.

The technical infrastructure can also be a problem on places where such infrastructure does not exists. The need of such infrastructure may require big investment by the customer.

Although it is very hard, meaby impossible to predict the time needed for return of the investment, because of the long term use of the systems for computer-based assessment, it is expected that the investment will be returned with time.

At the time when we started the development of the software, at the Institute of Informatics, there was already good existing technical infrastructure, which means that there was no need for additional hardware investment in order to implement the system. The costs for software development were also not very high, because its development by stuff from the Institute. These facts, and the expectations that the teachers and students will benefit with this solution, was good motivation for its implementation at the Institute.

B. Teacher perspective

The main goal for development of a system for electronic testing was to offer faster and more objective assessment of student knowledge, to deliver faster and personalized feedback about students achievements, which with the existing number of students at the Universities become almost impossible. The use of a system like this, should take some parts of the teachers job, giving them more time for other things.

The use of the system at the Institute was evaluated during its use, mainly through informal interviews with the faculty members which were using the system for creation of tests. From these interviews we concluded that the time teachers spend preparing the assessments, was are not significantly reduced at the beginning of their use of the system. At the very beginning of every course, a lot of time was needed to create the question bank for that course, in order to achieve consistency and security of the assessment. The process of question bank creation usually took one semester for every course. In the next semesters only short attention was needed for new question implementation and maintenance of the existing ones. The number of questions for some of the courses at the moment is more than 1700, and the whole question bank at the moment has 9735 questions. As Bull points out [9], question design is one of the most time consuming actions which needs to be taken at the beginning of use of any system for electro-nic testing. Further she concludes that from time point of view, the achievements can be seen with longer use of these systems. From our experience, we have concluded that there was time reduction after the complete course organization. When any course is completely organized, the assessment scheduling and evaluation takes minimal time. Also, because of the fast, detailed and personalized feedback which this sys-tem gives to the students, more time reduction was achieved.

C. Student perspective

In order to check the student opinion about the effectiveness of the system for electronic testing, a research about their opinion is help with the use of questionnaire, a method widely used in the education for doing research. We used this method because with its use, we were able to gather information about student opinion. The most of the questions asked were taken from already held questionnaires, according to Miller and Engemman [10], and Bocij and Greasey [6]. The most of the questions are Likert type with 5 values (1-5). The group to which this questionnaire was intended were those students which knowledge was assessed with this system before.

A total of 236 students participated in the study. The data gathered is evaluated using the system for electronic testing - using its module for surveys. Some of the results were exported to other statistical tools and analyzed further.

The first question was concerned with the easy of use. With this term we mean how easy was for the students to use the system, generate the tests, answer the questions and understand the results. Fig. 3 shows the results from the questionnaire from which we can see that most of the students (43,2%) think that the user interface is easy to use, which means that

they do not find any significant problems with its use. 28,4% think that the system is easy to use, and 23,7% that the system is very easy to use.

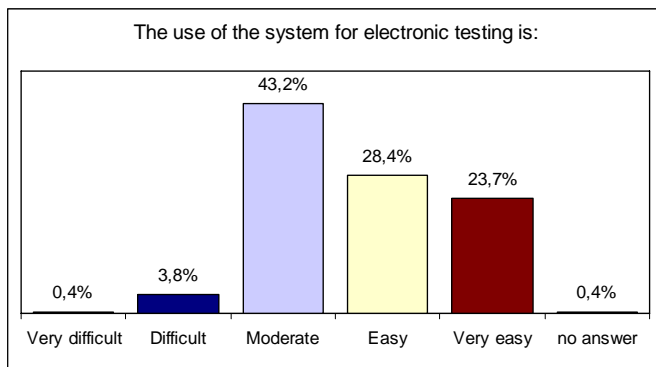


Fig. 3. Easy of use

The second question examines the range of skills student express using the system for electronic testing. According to the results, using a system for computer-based testing is offering possibility to express wider range of skills, than the traditional way of assessment (49,6%).

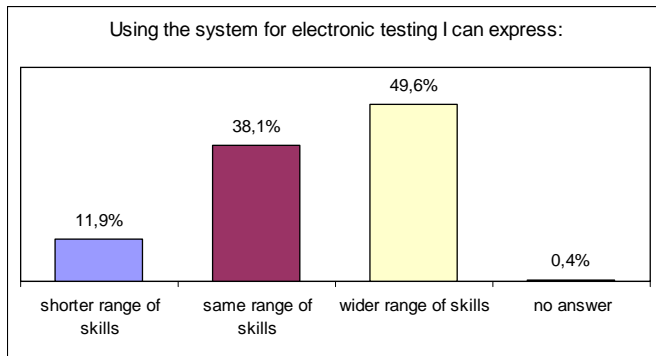


Fig. 4. Range of skills

Significant part of the students still think that same range of skills can be shown with both methods of assessment (38,1%), which is result of the use of a system like this for the first time, and at the same time using test delivery mechanisms very similar to the traditional way of delivering tests. 11,9% think that using this system they can express shorter range of skills compared to the traditional method. The results are shown in Fig. 4.

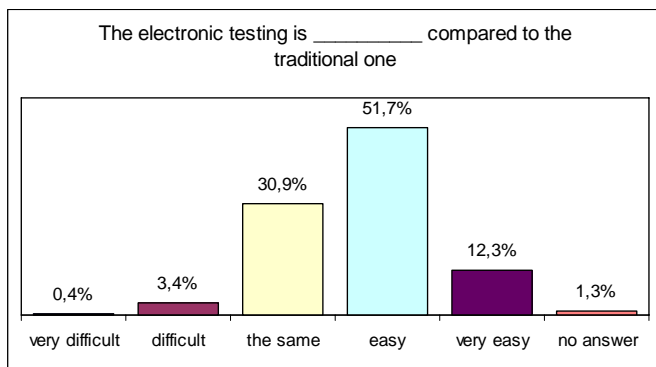


Fig. 5. Comparison of methods

The traditional method of assessment and the automated method of assessing student knowledge are compared in the third question. According to the results shown on Fig. 5, students think that the electronic testing is easier than the traditional one (51,7%), and 12,3% think that it is much easier. 30,9% of the students does not make any difference between these two methods thinking that they give same results, and 3,4% think that the electronic testing is harder than the traditional one.

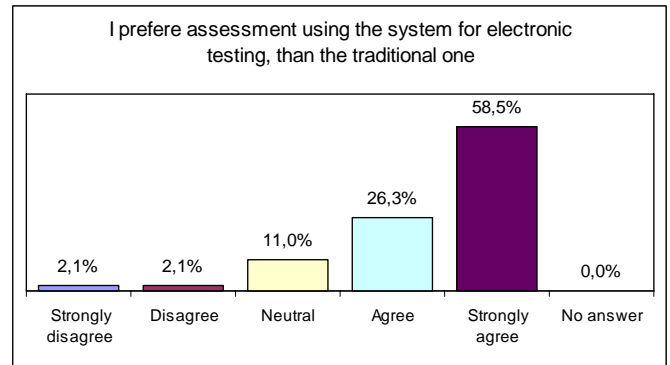


Fig. 6. Preferred method of assessment

The goal of the forth question is to find out which way of assessment of their knowledge the students prefer. Because of their experience with the both methods, the students are capable of comparing these methods. According to the results from this question shown on Fig. 6, 58,5% strongly agree that they prefer electronic testing, 26,3% agree, and 11% are neutral. Only 4,2% of the students does not prefer or does not prefer at all use of electronic testing.

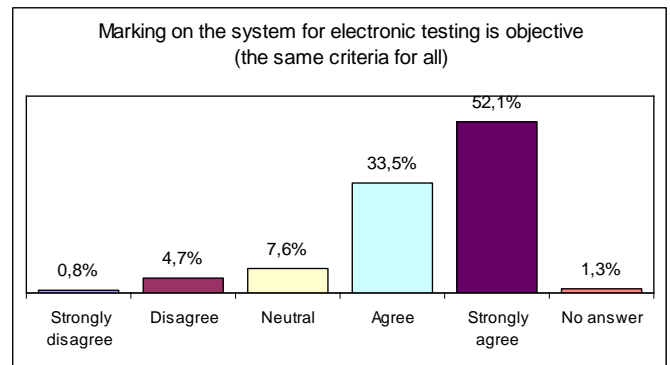


Fig. 7. Marking

One of the main advantages of electronic testing and computer based testing at all is the objective marking, because the answers entered by the students are not evaluated by human, but by the system itself according to some predefined rules. This way the students are avoiding the subjectivity in the marking process. The student opinion about the objective marking on the system for electronic testing eTest is evaluated in the fifth question. According to the results shown in the Fig. 7, the most of the students think that the marking is objective (52,1% strongly agree, 33,5% agree). 7,4% are neutral on this question, and 4,7% do not agree that the marking is objective for all students. We must point out here that the system for electronic testing is using marking model

with negative points, which was preventing the guessing of answers and was often criticized by the students.

In the following two questions, we evaluate the students opinion about the learning module. This module is implemented and used by the student in the last two semesters.

We evaluate the effectiveness of the module, in a sense if it is helping students to learn the course material. That means that the students which will pass all lectures using this module will learn the material faster and easier than using the traditional forms of learning. According to the results shown on Fig. 8, the students find the use of this module useful. 51,7% strongly agree that this module helps them learn the material easily, 36,9% agree, and 9,3% are neutral. 2,1% think that the use if this module does not help them learn the material easily and faster.

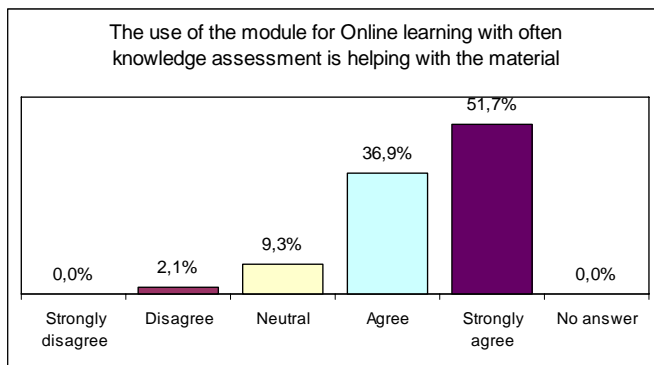


Fig. 8. Module for Online learning with knowledge assessment

The second question is concerned with the effectiveness of the module for online learning with often knowledge testing in achieving more knowledge than using the traditional forms of learning. The results shown on Fig. 9 showed that this module is very helpful in achieving more knowledge. 34,4% strongly agree with this, 37,7% agree, 22,9% are neutral. There are some small percentage of students 3,8% which does not agree with the claim, and 0,8% which strongly disagree.

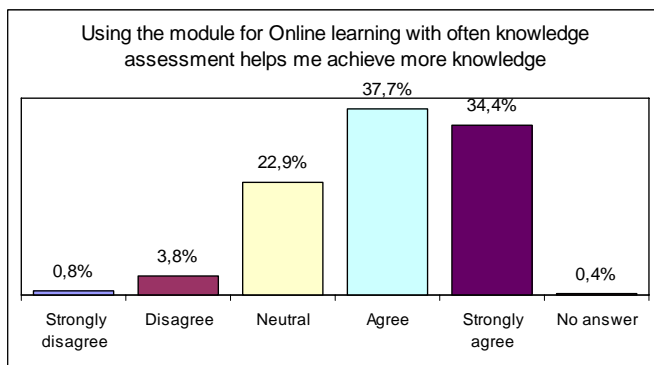


Fig. 9. Obtaining more knowledge using Online learning module

The last two questions were exploring the student opinion about the advantages that the system for electronic testing offer compared to the traditional forms of knowledge assessment. A list of functionalities was shown to the students and they were required to point out which of those features they think are advantages and which are disadvantages. The results shown on Figure 8 are showing that the main

advantages of electronic testing according to the students are: fast feedback (96,6%), self testing opportunity (96,6%), fast results and details about student errors (92,8%). Little lower percentage of the students think that the assessment is with less stress (80,5%) which as advantage is pointed out in other research papers [11]. 89,9% of the students think that this method of assessment offers more time for thinking.

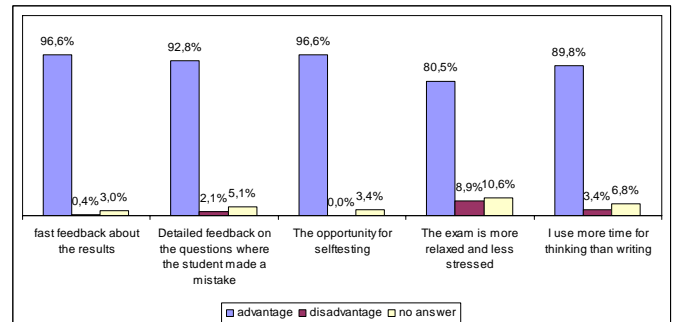


Fig. 10. Advantages and disadvantages

The questionnaire evaluated the student opinion about the system security and the opportunity for guessing. 63,6% of the students think that the system does not allow any form of cheating, while 13,9% think that the system does not prevent cheating. 54,2% of the students think that they can not get better results with guessing, and 26,7% still think that they can guess the answers, besides the implementation of the negative scoring method. On these questions there are lots of students that choose not to answer these questions.

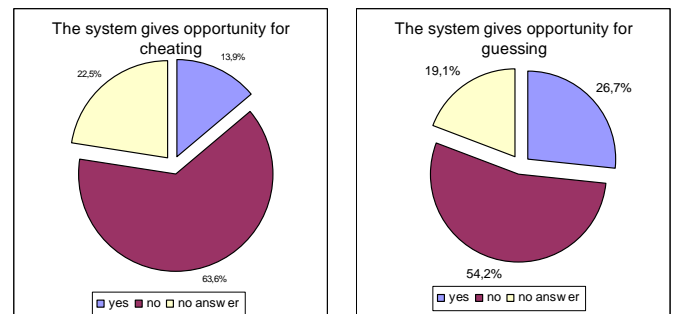


Fig. 11. Cheating and guessing

The last question was concerned with the student opinion about the future use of the electronic testing system.

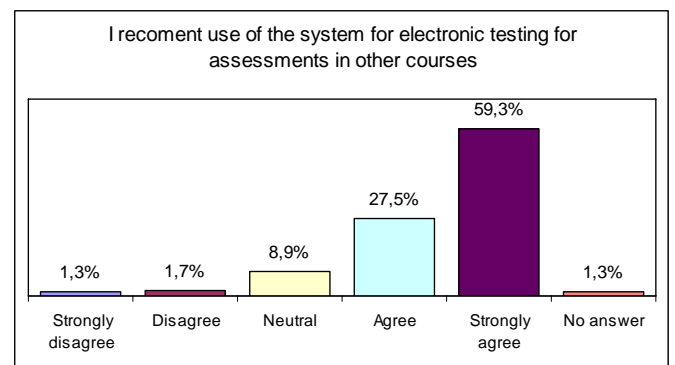


Fig. 12. Future use

According to the results, 59,3% of the students strongly agree that this system should be used in other courses as a tool for knowledge assessment, 27,5% agree and 8,9% are neutral. Only 1,7% does not support use of the system in other courses and 1,3% strongly disagree with its use.

The results from the questionnaire, with information about the standard deviation and mean for the questions which have Likert type of answers, are shown in Table 1.

Table 1. Mean and standard deviation of the questionnaire questions

Question	N	Mean	Std
The use of the system for electronic testing is:	235	3,7149	0,8865
The electronic testing is _____ compared to the traditional one	233	3,7296	0,7368
I prefer assessment using the system for electronic testing, than the traditional one	236	4,3686	0,9154
Marking on the system for electronic testing is objective (the same for all)	233	4,3305	0,8748
The use of the module for online learning with often knowledge assessment is helping with the material	236	4,3814	0,7428
Using the module for online learning with often knowledge assessment helps me achieve more knowledge	235	4,0128	0,8986
I recommend use of the system for electronic testing for assessment in other courses	233	4,4378	0,8288

V. CONCLUSIONS

The study on using computer-based assessment software as a tool for knowledge assessment, was based on student experience evaluated using a questionnaire, and on informal interviews with the faculty members which are using the implemented system.

The results from the informal interviews are showing that a system like the implemented one, is giving more opportunities to the teachers, slightly reducing their time spent on assessment preparation and evaluation of the student answers. The results show that the time reduction is shown after using the system for some time, not immediately.

The results from the 235 student questionnaires were used to evaluate student attitudes and perceptions toward automation of the assessment process with the use of computers in it. The students were evaluating the easy of use, marking objectivity, opportunity to achieve more knowledge and the advantages of this form compared to the traditional forms of assessment. Results show that the student opinion was positive, and that they have accepted the use of the system, and they recommend its future use in other courses.

As technology is becoming the norm for delivery of courses, computer based assessment will become the norm for delivery of testing.

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