Modern distance examination using the latest technology - the *E-matura* project

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ABSTRACT: This paper demonstrates a system for conducting modern distance examinations, including several important features such as analysis of graduate characteristics. The issue of how new technology can help in conducting examinations is presented and discussed. The data collected during the examinations were used for a comprehensive analysis of the knowledge acquired by graduates, as well as to draw conclusions concerning the educational process. Using the latest technology, the authors have created a rich interface that facilitates the conduct of examinations. It allows the creation of e-examinations with questions that contain images, animation, video, sound recordings and open ended questions. The authors have also had to meet a challenge concerning the requirement for the examinations to be highly accessible. All of these issues and topics are raised and discussed in this paper.

INTRODUCTION

The *E-matura* system was created under the direction and supervision of Professor Sławomir Wiak at the Technical University of Łódź, Poland, and under the auspices of the Ministry of Education. Examinations were held in October 2009, May 2010 and April 2011, and they attracted positive coverage by the Polish media. Several thousands of students from all over Poland took the matriculation examination in mathematics at the same time via the Internet. IT corporations, such as IBM and Microsoft, committed themselves to the project supporting the programming team with professional servers and software.

The examination included both test and open ended questions. Students valued the application of the newest technologies, animations in questions and the speed of results being available. Teachers received the results of all their students. The character and features of the project enable deep and precise statistical analysis of answers given by students to improve the quality of the education. The project is under continuous development. After its end, the product will be fully ready for use on a large scale, but the goal is not just to create a reliable system to conduct examinations at a distance. In 2013, the product will be fully ready for use on a large scale.

RICH USER EXPERIENCE

Today's systems for conducting examinations focus primarily on the so-called test questions known as closed questions, which consist of the question itself and a set of possible answers. Thanks to modern technology such as Silverlight, the E-matura system could go an extra step, to include open ended questions. This technology allows the construction of questions that include such elements as:

- Interactive animations;
- Checkboxes;
- Interactive areas where the user can drag the selected items;
- Interactive areas where the user can highlight a range of numerical values.

These few examples show that the possibilities of a modern examination go beyond the traditional forms of the test examination. Further, using animation and appropriate graphics, an examination becomes more friendly to people who are often stressed during the test. This is especially important for young people who prefer this form of examination. For them, it is much more interesting than the traditional examination methods. Figure 1 shows a picture that highlights a range of numerical values.

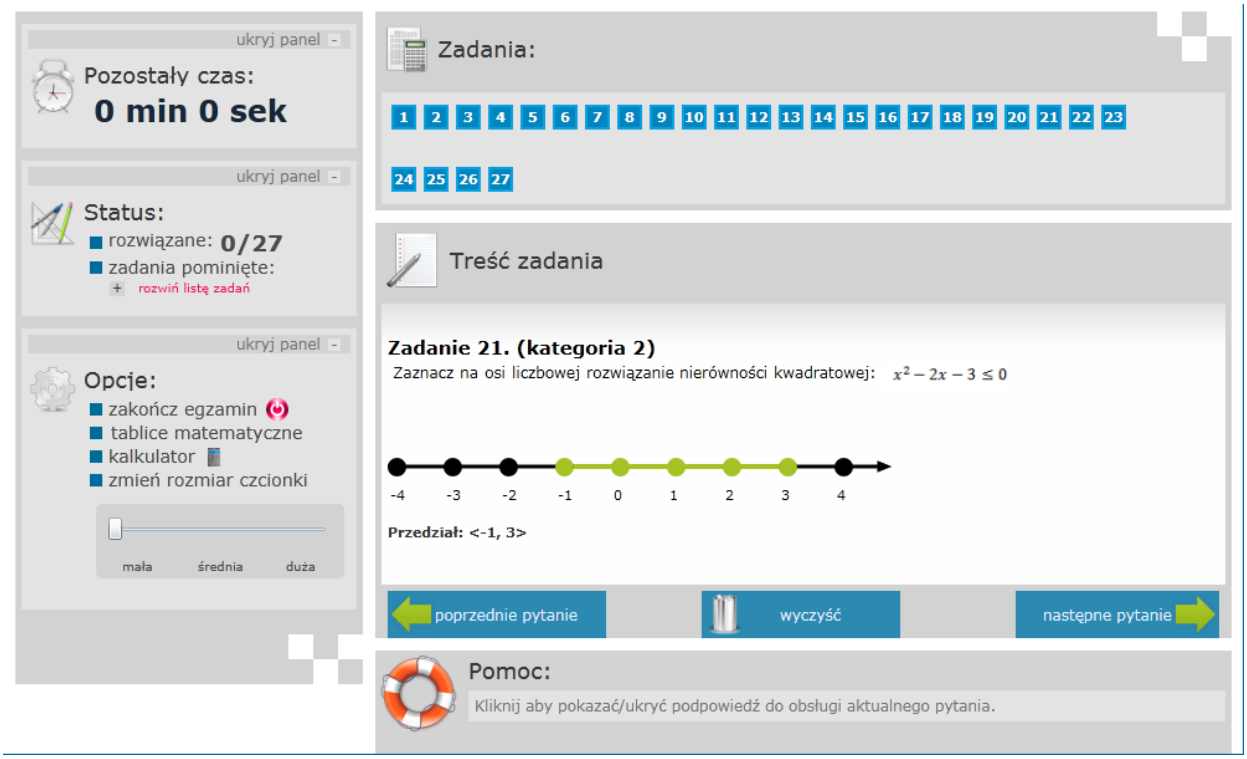


Figure 1: Highlighting a range of numerical values.

A rich interface also makes learning enjoyable as demonstrated in this team's another project called IMSI e-platform. The use of a modern interface gives new opportunities in e-learning. The system has many features to improve the efficiency of learning. Students can use features such as the *virtual board*. Teachers can draw something, which will appear in the student's application. What is more, one can quickly and easily write notes. There are two ways of adding student notes to the lecture:

- One can add notes directly to the lecture file - students are able to highlight some part of text and add a text note;
- In the student application, there is a special tab with notes. The notes tab includes virtual sheets of paper where student can draw or write thoughts.

Other features which improve effectiveness are:

- Audio/video streaming – students are able to see and hear the teacher during the lecture.
- *Chat*, which enables asking questions directly to the teacher.

The use of these features is possible through modern interface.

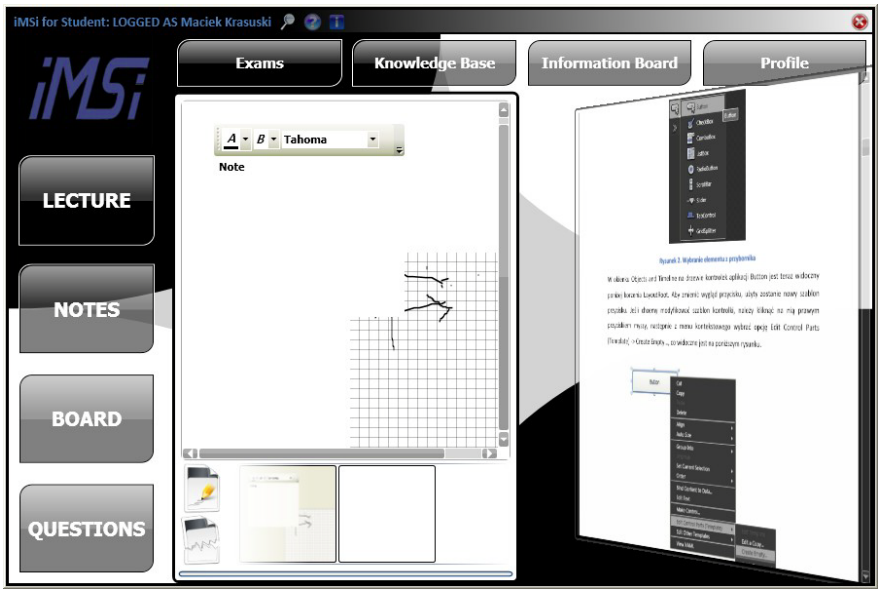


Figure 2: Virtual sheet of paper for notes and lecture in 3D.

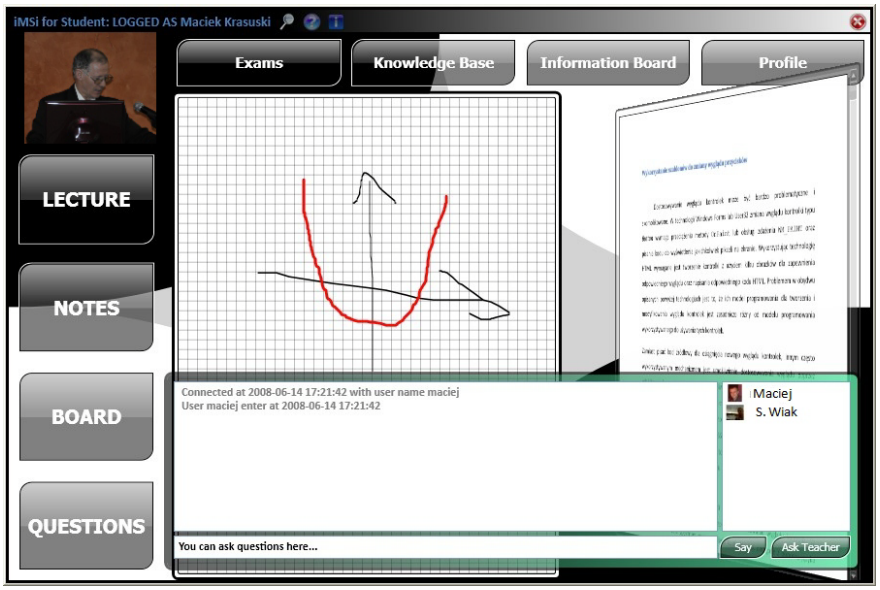


Figure 3: Chat with a teacher and audio/video streaming.

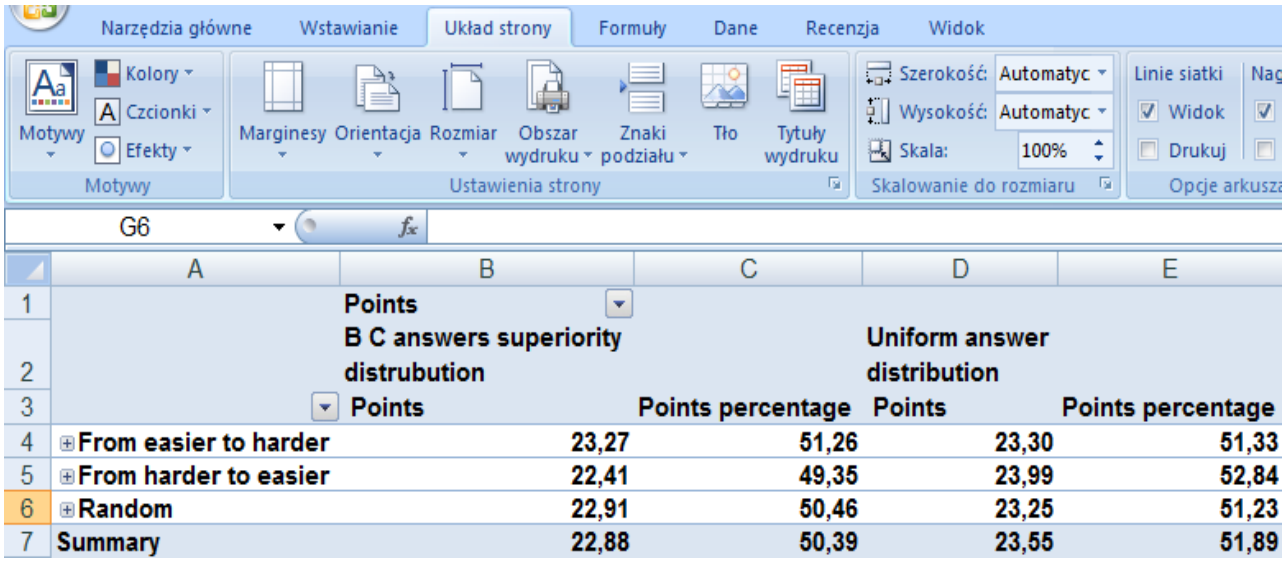
COMPUTER-AIDED ANALYSIS OF GRADUATE CHARACTERISTICS

A system for conducting modern distance examinations should provide computer-aided analysis of graduate characteristics. Teachers, examiners and authorities are trying to improve the learning process. Without additional information the process is limited - many causes contributing to the learning results are not examined.

The analysis of a particular school level or of the whole country will not necessarily show all the reasons. E-matura offers not only up-to-date examinations, but also great opportunities to check the process of teaching and learning. Computer-aided diagnosis of mathematical graduates can be divided into groups of end users:

- Students: Results compared with the class, school, country. Which parts of the program should have more emphasis placed? The E-matura system is also available for students to check their knowledge before the examination;
- Teachers: They will see results for the whole class, with a comparison to the average result from the school, country and city. Also, they will be able to compare students' results with the results of students attending to the same type of school;
- Authorities: They will be able to ascertain which type of schools recorded the weakest results, how examination results are affected by the size of the city or the region, and how other factors affect the results.

End users use different interfaces. For teachers and students, the result of analysis will be presented in the system, for the authorities in a easy to use spreadsheet file.



	A	B	C	D	E
1		Points			
2		B C answers superiority distrubution		Uniform answer distribution	
3		Points	Points percentage	Points	Points percentage
4	From easier to harder	23,27	51,26	23,30	51,33
5	From harder to easier	22,41	49,35	23,99	52,84
6	Random	22,91	50,46	23,25	51,23
7	Summary	22,88	50,39	23,55	51,89

Figure 4: The picture shows sample analysis.

During each examination, hundreds of thousands of responses were collected. If the students answered a given question several times changing their answers, the system recorded all their steps. The time of those answers was given, and how many times they came back to each question was also registered. The results of the questions for the student, school or country can be analysed. What is even more, three sets of questions were implemented - from the simplest to the most difficult, from the most difficult to simplest and random. Further, it is also possible to analyse how the problem of initial questions affects the examination.

For the purpose of this research, two versions of answers were added: in the first set of 70% questions, the correct answer is hitting on B or C (however 30% is A or B), in second the answering order is completely random. The computer print-out is shown in Figure 4.

Being able to connect the correctness of answers to a given question with the region, city, or type of the school, provides the possibility of drawing conclusions concerning the improvement of the quality of the educational process. One can also conduct an analysis on how the size of the city affects the results.

After the examination, students also undertake a survey questionnaire. They answer several questions, covering such issues as: whether they were attending the tutoring, who was the authority, how much time per day they spent at the computer using the Internet, if both parents work, whether parents help them in their learning. Answers to these questions are then combined with the students' results, and the partial results of the questions. It is possible to analyse these data at the school level, city, region or nationwide. The responses allow examiners to look for a correlation between the results of students and factors contained in the survey questions.

ENSURING HIGH ACCESSIBILITY

The classic examination system, running in the on-line environment is activated on a single Web server, which handles all the traffic generated by this and other applications that are installed on the computer. This solution works in most cases because the average numbers of people who use the Web server at any one time are not able to overload the server resources. In a situation where tens of thousands of people are referred to a single server at the same time, overload is unavoidable. It is because any connection to the server requires a certain allocation of memory and CPU time.

To meet the requirement of high accessibility for the examination, the solution based on the so-called *load balancing* was applied. The solution is to build a cluster of servers in which one can distinguish two main parts. The first one is a computer constituting the AP to the examination. All connections are directed to this computer, but they are not directly supported, but only transmitted to the computers in the cluster. Based on the selected load management algorithm, this server redirects traffic to the least loaded server in the cluster.

This solution is highly scalable and allows for virtually unlimited expansion of the cluster. The only limitation is the Internet bandwidth at which the communication takes place. An additional feature that may satisfy this server is decoding an encrypted SSL message and passing it along as decrypted message. This causes a reduction of the burden on the target servers; however, with a large number of connections, it may cause an overload of the server balancing traffic.

In this project with IMSI e-platforms, the developers met with similar problems, which needed to ensure high accessibility of the system for the final users. In the e-learning platform, the solution architecture consists of client computers connected to a central server and teacher computers, which also connect to a central server. The teacher's computer has a very important role in this case, because from this computer the audio-video signal and synchronisation signal are transmitted to the server and, then, are sent to the connected students' computers. Thanks to such an infrastructure, the teacher's computer is not overloaded with appeals from users' computers. Experience gained from the above IMSI e-platforms was used in the design of the E-matura project.

CONCLUSIONS

E-matura is not only a modern system for conducting examinations at a distance, it is also a computer-aided mathematical tool for analysis of graduates. The collected data can be used to analyse at different levels of detail. It allows the collection of information at the level of student responses to individual questions, and there is no problem in comparing with results at the national level, for example. Survey questionnaires completed after the examination allow examiners to look for correlations between various factors and examination results.

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