

E-tutoring as part of the e-examination - the use of data warehousing and data mining to assist the learning and teaching process

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ABSTRACT: For the past two years, students have been using the *E-matura* system to sit for a matriculation examination in mathematics. In this paper, the authors endeavour to demonstrate the projected e-tutoring module, which will become an integral part of the *E-matura* system. Using the latest technologies, a sub-system is being developed that can be used for learning by students, along with the diagnosis of their current knowledge. Moreover, teachers will be able to use a platform to diagnose students' knowledge and ask them to do their homework. 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, under the auspices of the Ministry of Education. Examinations were held in October 2009, May 2010 and April 2011, and they attracted considerable positive coverage in the Polish media. Several thousand 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 the required software.

The examination included both a test and open-ended questions. Students valued the application of the latest technologies that enables animations in given questions, as well as the instantaneous availability of results. Teachers received the results of all their students. The characteristics and features of the project facilitate in depth and precise statistical analysis of the answers given by students to improve the quality of education. The project is under continuous development. In 2013, the product will be operational for use on a large scale, but the overarching goal is more than to create a reliable system to conduct examinations at a distance.

Further, based on the results of a mathematical diagnosis, the system will help students and teachers to prepare for the examinations by an e-tutoring module currently under development.

E-TUTORING - PROBLEM DEFINITION

In the e-examination area the following problems are being diagnosed:

- Test results alone do not give enough information to students for the efficient preparation for the examination.
- It is necessary to save results in every part of the programme and present the learning progression over time for students and teachers.
- The possibility of assigning additional tasks to students by the teacher.
- The system provides additional tasks for students in necessary areas for repeating by them, to achieve better final goals.

E-TUTORING MODULE

E-matura provides a computer-aided analysis of graduate characteristics. The *E-matura* system is built to collect as much information as possible in addition to the response, which after processing can be analysed in order to draw conclusions. The system collects information to answer questions such as:

- Which questions were the hardest?
- How much time a student needs to solve a task?
- How many times a student comes back to a question?
- How much time does a student need to complete the whole examination?

The system collects detailed information on each student and each question and stores it in its database. If the student answered a given question several times, or changed the answer, all his/her steps are recorded by the system. The time taken to give every answer, and how many times the student went back to the question, are also registered. During each test, the system records over 500,000 responses for several thousand students. All information regarding the questions and the answers provided are embedded in the context of the user, the class and school.

As mentioned earlier the e-tutoring module is currently being developed. It will support the process of education for both students and teachers. This module will form an integral part of the *E-matura* system.

E-TUTORING MODULE FOR TEACHERS

The current plan is to provide students with additional tasks for the subjects diagnosed by the system as needing to be repeated. Based on this diagnosis of the weakest areas for the student or class, the teacher will be able to assign tasks to a particular student or to the entire class. The system will show who has done their homework and will check the correctness of their answers. The teacher will not have to check the homework. Tasks will be drawn from a pool of tasks from previous examinations or will be generated automatically by the system - in the tasks for which it is possible. Work is currently in progress that will allow teachers to add their own questions to the system so that the teacher will be able to use the system to prepare students for the examination questions.

Moreover, teachers will be able to monitor the progress of each student individually or at the class level. The system will present an overall assessment of students' knowledge, as well as individual parts examined by the program. What is even more, the e-tutoring module will provide access to historical data for each student and class. It is possible to process aggregated data (current and historical) from the *E-matura* system in Microsoft Excel spreadsheets. Furthermore, it is convenient for the user to apply such familiar tools. Figure 1 presents a sample report with the examination results for open questions, whereas Figure 2 presents a sample report with the examination results for closed questions.

Question		Time spent to solve question [min]					Points for question				
Category	nr	avg	min	max	stddev.	median	avg	min	max	stddev	median
Open questions	1	14,7	0,1	322,0	19,54	10,1	0,6	0	2	0,90	0
	2	6,9	0	274,0	10,06	4,1	0,7	0	2	0,82	0
	3	6,1	0	182,2	5,38	5,6	1,0	0	2	1,00	0
	4	6,6	0	33,6	4,92	5,4	1,2	0	3	0,76	1
	5	2,5	0	167,6	4,05	1,9	0,1	0	2	0,48	0
	6	6,6	0	53,8	4,64	5,5	3,4	0	5	1,26	4
	7	7,3	0	117,4	5,64	6,2	1,9	0	4	1,25	2
	8	5,0	0	176,2	7,13	4,1	0,3	0	2	0,74	0
	9	7,3	0	60,7	5,11	6,4	0,1	0	2	0,26	0

Figure 1: A sample report with the examination results for open questions.

Question		Time spent to solve question [min]					Points for question				
Category	nr	avg	min	max	stddev.	median	avg	min	max	stddev	median
Closed questions	10	1,6	0	16,4	1,45	1,3	0,9	0	1	0,33	1
	11	1,0	0	18,1	1,05	0,8	1,0	0	1	0,19	1
	12	1,3	0	16,8	1,35	1,0	0,8	0	1	0,39	1
	13	2,2	0	22,5	2,29	1,5	0,4	0	1	0,48	0
	14	2,1	0	52,0	2,53	1,4	0,3	0	1	0,46	0
	15	1,9	0	53,7	2,41	1,2	0,6	0	1	0,50	1
	16	2,3	0	17,7	2,26	1,7	0,7	0	1	0,46	1
	17	1,7	0	46,7	2,33	0,9	0,6	0	1	0,48	1
	18	1,9	0	18,7	2,06	1,3	0,7	0	1	0,45	1

Figure 2: A sample report with the examination results for closed questions.

Using this system, teachers will obtain answers to questions such as:

- Which questions were the hardest?

If the student answered any given question several times and changed responses, the system records all his/her steps. The time taken to provide every answer and how many times the student went back to the question were also registered. The results of the questions by student, school or country, can be analysed.

- Which parts of the teaching programme should be repeated by students?

Teachers will receive detailed information on the areas requiring additional treatment or repetition.

- The student results against the class, school, city and country.

Teachers will see the results for the whole class with a comparison with the average result for the school, city and country. It will be possible to compare students' results with the results of students attending the same type of school.

Teachers will also be able to carry out quantitative analyses of the results, based on a statistical analysis. The set of parameters that can be analysed as follows:

- Ease of the task/test - the ratio of the number of points obtained by students to the maximum possible number of points for a task or test;
- Difficulty of the task - the ratio of the number of students who have not solved a task properly to the number of students;
- The arithmetic mean of the results - the average score obtained by the test group of students - for example, a particular class;
- Median - the result of the middle set of examination results of a particular population - for example, a particular class;
- Mode - the most common value among a group;
- Area of typical results - results interval on the scale located between the sum and arithmetical difference of the arithmetic mean and standard deviation;
- Standard deviation - a measure of variability or diversity, allowing to determine the range of typical results;
- Variance - a measure of how far sets of numbers are spread out from each other;
- Stanine scores [4][5].

E-TUTORING MODULE FOR STUDENTS

Using the system, students will be able to solve the tasks assigned by the teacher, and after solving the tasks, they will receive their results and the correct answers immediately. The teacher will be able to add some theoretical information to each task. The theory bit will appear should the answer be wrong or at the user's request.

Further, students will be able to join a trial examination at a convenient time. On completion of the trial examination, students will see the results immediately, with information on what they have done wrong in each of the tasks, so that they do not make the same mistakes in the future. In the case of problems with solving the tasks, students will be able to mark all the tasks they want to come back to after the examination. Moreover, students will be able to monitor progress of their knowledge in a convenient form, such as graphs.

What is more, the system will diagnose which part of the programme should have greater emphasis placed on so that students will be able to choose only tasks from that part. If the required number of correctly solved tasks is achieved, the system will mark this part of the programme as completed by students.

TECHNOLOGY

The researchers plan to apply business intelligence (BI) techniques. Business intelligence tools are divided into groups:

- OLAP (On-Line Analytical Processing) - for the multidimensional analysis;
- Data Management - allows storage of data - data warehouses;
- Exploration - data analysis algorithms.

Business intelligence is directly linked to the data warehouse concept through which data are stored in a consistent format without affecting the On-Line Transaction Processing (OLTP) transactional system. OLTP systems are designed for efficient processing of transactions during the current activities of the project. The purpose of OLTP systems is to store data while ensuring concurrency and set the number of transactions (number of transactions per unit of time - usually per second). For large data sets, OLTP servers have a limited capacity for carrying out an in-depth analysis of current data and especially historical data.

OLAP systems (On-Line Analytical Processing) are used for a multidimensional data analysis in enterprises, including the following:

- Trend analysis;
- Financial condition and profitability of the company;
- Human resource management and inventory;
- Predicting customer response.

The data analysis is also related to the concept of exploration/extraction of data - data mining techniques - *move beyond simple data analysis to identify hidden trends, problems, or relationships in the data. After insights are extracted from patterns, clusters, and trends, people can better identify the root cause of problems and predict future outcomes* [1].

A Microsoft SQL Server 2008 R2 is used as a database to collect data during the examination. It is envisaged that the researchers will build their own business intelligence solution using the Microsoft SQL Server. In addition, the researchers do not exclude the possibility of using other software produced by companies such as IBM or Oracle.

CONCLUSIONS

On completion, the *E-matura* system will be a tool for more than e-examinations. With the availability of the latest technology, the researchers envisage building an e-tutoring module that will enable support for education of teachers and students.

Since teachers have access to a mathematical diagnosis of their students, they will be able to monitor the progress of students' knowledge and assign a variety of tasks for them to solve. The e-tutoring module will make it possible to test students' knowledge, in the same format as the final test, on this platform.

In addition to completing tasks assigned by teachers, students can solve tasks in those areas that cause them the most problems, and they can monitor their progress and how much more they still have to learn.

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