

Computer-aided mathematical analysis of graduates - Business Intelligence in the *E-matura* project

D. Jeske, M. Krasuski & R. Stryjek

Technical University of Łódź
Łódź, Poland

ABSTRACT: For past two years, students have been using a system to sit for a matriculation examination in mathematics. The authors demonstrate in this paper how Business Intelligence techniques and data analysis could improve the mathematical analysis of graduates. The data collected during the examinations are used for a deep analysis of the graduates' knowledge, and to draw conclusions concerning the educational process that took place. The analysis takes place at the chosen level of granularity. Using this system, one can analyse the results at the level of student, school, region or country.

INTRODUCTION

The *E-matura* was created under the direction of Professor Sławomir Wiak at Technical University of Łódź, and the development has been carried out under the auspices of the Ministry of Education. The examinations were held in 2009, 2010 and 2011. Several thousand students took a matriculation examination in mathematics at the same time via the Internet. The project is under continuous development. On completion of the project, the final product will be ready for use on a larger scale. The goal is not just to create a reliable system to conduct examinations at a distance; but also to create a system for computer-aided analysis of graduate attributes.

PROBLEM DEFINITION

Teachers, examiners and authorities are trying to improve the learning process. Without additional information the process is limited - many of the factors contributing to the learning results are not examined. Analysis only at the level of a particular school or for the whole country does not show all the reasons. *E-matura* offers not only a modern examination, but also great opportunities to study the process of teaching and learning; for example, comprehensive analysis enabled by *E-matura* includes:

1. Which questions caused the most difficulty?
2. How does the sequence of questions and answers affect the results?
3. How does the city region, type of school affect the results?
4. How do factors not directly related to examination factors affect examination results; for example, whether students participated in tutoring had a computer with Internet access, etc.

Computer-aided analysis of mathematics graduates can be divided into groups of end users:

1. Students - the result against the class, school, country. In which parts of the programme should greater emphasis be placed;
2. Teachers - which parts of programme should be repeated with students. How the results of one teacher's students relate to the background of the school and country;
3. Authorities - which types of school recorded the poorest results. How does the size of the city or the region affect the result of the examination. How do other factors affect the results?

End users use different interfaces. For teachers and students, the results of the analysis are presented in the system, for the authorities in an easy-to-use spreadsheet file.

SOLUTIONS

- Which questions were the hardest?

During each examination, hundreds of thousands of responses were collected. If the student answered any given question several times changing the answer (responses), the system recorded all his/her steps. The time of giving every answer and how many times the student went back to question were also registered. The results of the questions by student, school or country, can be analysed.

- How does the sequence of questions and answers affect the results?

Three sets of questions were implemented; from simplest to the most difficult, from the most difficult to simplest and randomly. It is possible to analyse how the problem of initial questions affects the examination. For research purposes, two answer versions were added: first into 70% questions the correct answer is hitting on B or C (however, 30% is A or B), in second this order is completely random.

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

Figure 1: A report on how initial questions and correct answers order affect the examination results.

- How do the city region and type of school affect the results?

Because of the capacity to connect the correctness of answers to the given questions with the region, city, or type of the school, it is possible to draw conclusions concerning improvements to the quality of the education process.

Population	Average points	Standard deviation	Number of schools
>500 000	19,71	6,23	56
10 000 - 50 000	22,95	5,69	73
100 000 - 500 000	23,88	6,72	32
50 000 - 100 000	24,77	5,98	24
<10 000	25,97	5,48	72
Total average	23,90	5,82	257

Figure 2: Report on how the size of the city affects the examination results.

In addition, one can also analyse how the size of the city affected the result. Unfortunately, not enough data have been gathered to draw strong conclusions, but the statistical selection of schools in the future will enable conclusions to be drawn.

- How do factors not directly related to examination factors affect the examination results; for example, participated in tutoring, had a computer with Internet access?

After the examination, students respond to a questionnaire. They respond to questions such as: whether they attended tutoring, who the authority is, how much time per day they spent at the computer using the Internet, if both parents work, whether parents helped in learning. Answers to these questions are combined with the students' results and the partial results of the questions. It is possible to analyse these data at the level of school, city, region or nation. The

responses allow for an examination of correlations between the results of students and factors contained in the survey questions.

- The student result against the class, school, country. In which parts of the programme should greater emphasis be placed?

The E-matura is available also for students to check their knowledge before the examination. Currently, only the result is displayed. A student can test his/her knowledge in a test similar to the matriculation test. Work is currently being carried out on the displaying a full analysis of his/her knowledge: what areas need additional study, the subjects of these areas that should particularly be repeated.

The current plan is to provide students with additional tasks for the subjects diagnosed by the system for repeating. Tasks will be drawn from a pool of tasks from previous years or will be generated automatically by the system - in the tasks for which it is possible.

- Which parts of programme should be repeated by students?

The teacher will see the results for the whole class with a comparison to the average result from the school, country and city. It will be possible to compare students' results with the results of students attending the same type of school. Moreover, each student will receive detailed information on areas requiring additional repetition.

CONCLUSIONS

E-matura is not only a modern system of examinations at a distance, but it is also provides a computer-aided mathematical analysis of graduates. The use of Business Intelligence can support the education process at every level. Students can check their knowledge, teachers can find out what needs repetition, and the authorities can examine how different factors affect students' knowledge in order to prevent problems.

The collected data can be used to analyse different levels of detail. So far, information at the level of student responses to individual questions has been collected, but it will also be possible to analyse results, for example, at the national level. Surveys completed after the examination allow for correlations between various factors, and examination results to be sought.

REFERENCES

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