Online Courses of Mathematics for Entrance Exams

Jana PASÁČKOVÁ
Prague University of Economics and Business, Czech Republic
jana.pasackova@vse.cz

ABSTRACT
This paper deals with the results of students during the preparing courses of mathematics for entrance exams at an university. These courses take place every year and since the Covid-19 period, they are not only face-to-face, but also online. The study involves students of secondary schools who apply to the university of economics. This report compares results of tests of two different classes of these students and from different parts of mathematics. These tests are in the form of online quizzes. We do not prove if there are differences between the scores of students of short-time or long-time courses. In addition, we compare the results with the students from the year before. We also emphasize the more problematic topics of mathematics.
Keywords: entrance exams, on-line courses, mathematics, online quizzes

INTRODUCTION

During last years, we noticed the decreasing level of knowledge of mathematics between students who had registered at universities. There was the big slump during the Covid-19 period as well. The marking of school-leaving exams from mathematics had been set more lenient than in previous years. Thus, now many universities try to increase the level of knowledge of students and prepare some courses for students. There are two types of courses, short-term or long-term. The short-term courses take place often during the summer or September. And the long-term courses often take place during the same school years when students prepare for the school leaving exams.

In this article, we discuss these courses which take place at the Prague University of Economics and Business (PUEB). The Department of Mathematics prepare courses of mathematics which increases the possibility of success of students during the entrance exams. Since to be accepted at some of the bachelor programmes, students have to gain 100 % of points from the tests (mathematics, foreign language and other subject depending on their field of study). Thus, these courses are very helpful even for excellent students.

During the pandemic period, we started to offer these courses in on-line version. And now, we continue with this trend and students can choose on-line courses as well as face-to-face courses at the university.
After accepting at university, students of all bachelor programmes have to pass an exam from Mathematics. This implies the importance of entrance exams. The course of Mathematics consists of linear algebra and mathematical analysis. See the syllabus:
- propositional and predicate logic,
- matrix algebra, rank of a matrix, determinants, systems of linear equations,
- limits and their basic properties,
- derivative of the function of 1 and 2 variables and their applications,
- integral calculus of one variable,
- differential equations.

These topics play an important role in economics applications. For the more detailed content of the course see Klůfa (2019). The examples of final exam can be seen in the textbook Otavová and Sýkorová (2020). In addition, Klůfa (2017) compared the results of students during the entrance exams depending on the type of the faculty and Otavová and Sýkorová (2016) investigated differences in results of exams of mathematics obtained by students of different faculties.

In Glivická (2020) and Glivická (2019), it is described the beginning of on-line teaching period at PUEB. At our university, we used MS Teams and Zoom for teaching, as in many other schools, see for example Barry et al. (2020), Pal et al. (2020).

During the on-line teaching period we had to face some problems. Between the more important problems for teachers fell the lack of the necessary hardware and no previous experiences with online teaching. In addition, teachers had only very short time to convert all their materials in online form. On the other hand, students had to

face learning individually and took responsibility and learned on their own without supervision. Despite these problems, students mentioned in the university survey that they would prefer other study resources then textbooks and use video tutorials during their self-study time in the non-online period as well.

To conclude, we can mention some foreign research about the online teaching. For example, in Dhawan (2020), they discussed this situation in India together with deprivation due to social class, ethnicity, etc. This topic was important in the Czech Republic as well, because not every family had at home enough computers or some additional equipment such as camera, microphone, tablet. Bozkurt et al. (2020) claimed that students would not remember the educational content delivered but how they felt during this period. On the other hand, Ananga et al. (2017) mentioned, already before the pandemic period, that the learning online required varying of pedagogy and practice to ensure effective learning outcomes.

THE COURSES OF MATHEMATICS
In academic year 2021/22, we offered on-line as well as face-to-face courses of mathematics for students who would like to pass the entrance exams at PUEB. Students could choose from seven possibilities (terms) of these courses. Four of these courses were on-line. The courses are 32, 40 or 52 hours long.

Long-term courses started during October and November. Short-term courses started in January or March.

In this paper, we deal with the entrance exam courses which takes 52 and 32 hours. The longer course started in November 2021 and finished in April 2022. The second one course started in January 2022 and finished in May 2022. Both courses were taught in on-line form. Every week there was one lesson which takes 2 academic hours. The courses included the following topics:
- expressions processing,
- linear and quadratic equations and inequalities,
- systems of linear equations,
- arithmetic and geometric sequences,
- exponential and logarithmic functions, equations and inequalities,
- trigonometric functions and equations,
- complex numbers,
- combinatorics,
- analytical geometry,
- word problems.

We used the platform MS Teams to teach and distribute materials. Students followed how the teacher solved some examples and then they have the possibility to ask questions and to solve some problems themselves.

The problem with the lack of personal contact with students, we solved using the interactive quizzes. Thus, we tried not only to teach, but to involve the students and to avoid that they get bored, or they will not understand and feel shame to ask.

INTERACTIVE QUIZZES
At the end of almost every lecture, students had to fulfill an interactive quiz. It usually contained five problems from the discussed topic, and questions had a time limit.

We used online interactive real-time voting software Mentimeter to create these tests. Mentimeter is a presentation software from a Swedish company. It is used to create presentations with real-time feedback. We built interactive presentations with the online editor. We added questions, polls, quizzes, slides, images and more to create fun and engaging presentations. The audience used their smartphones or computers to connect to the presentation where they can answer questions. The teacher was able to visualize their responses in real-time to create an interactive experience. It helped to break the ice. We encouraged the students to pass these tests and then to speak about the problems they had had. On the other hand, they were able to see the comparison with other students. Then they could think about their knowledge.

Quizzes obtain problems with open-ended and closed-ended questions. To answer an open-ended question, students had to write a number. And to answer a closed-ended question, students had to choose from a distinct set of pre-defined responses. See some examples of these questions in Pasáčková (2022).

When all students had answered or the time limit had ended, then the teacher as well as students saw the right answer and number of answers for all possibilities. At the end of the quiz, we saw the leaderboard. And the winner

was the one who had calculated the fastest and with the less mistakes. Students could use nicknames, so the evaluation was anonymous.

THE STUDY

Students fulfilled quizzes differentiated by the topic. There were 18 quizzes in the course which took 52 hours and 14 quizzes in the course which took 32 hours. There were 69 students in the longer course and 63 in the short-term course.

These tests were very helpful for getting feedback from students and to see if there were some problems with any topics. The success rate was influenced by the time limit of quizzes as well. Average time for calculating one test was 20 minutes and almost every quiz had 5 (or 4) questions.

The success rate of each quiz, it means how many percent of students wrote the right answer, is shown in Table 1. These two groups have same questions in the tests, thus we highlighted in the table which group was more fruitful.

Table 1: Comparing of success rates of the long-term and short-term courses.

Comparing of success rates	average success rate in the course of	
Topic	52 hours	32 hours
expressions processing	42%	46%
linear equations and inequalities	43%	35%
linear and quadratic equations	54%	-
quadratic equations and inequalities	53%	51%
irrational equations	41%	-
equations with absolute value	58%	47%
exponential equations and inequalities	53%	54%
logarithmic equations and inequalities	43%	38%
exponential and logarithmic equations with absolute value	60%	66%
systems of equations and inequalities	44%	45%
arithmetic sequences	36%	59%
geometric sequences	62%	-
trigonometric functions	36%	26%
trigonometric equations	55%	-
complex numbers	53%	73%
Combinatorics	50%	34%
analytical geometry	56%	47%
word problems	35%	21%

Students of the long-term course were more successful in 8 quizzes and the others in 6 quizzes.
All students had biggest problems with word problems. This topic is usually the most problematic, because there is not any specific way how to solve all these problems. They can encounter problems which they can easy solve by the systems of equations, or using percentage, or problems about common work, some problems about areas and volumes etc.

The second problematic topic are trigonometric functions. This topic is always one of the most complicated at secondary schools and it is often hated by students, since they have to remember many formulas, graphs and values of these functions. Many students have problems with this topic.

On the other hand, between the more successful quizzes we can mention quizzes with the topic of exponential and logarithmic equations, equations with absolute value, complex numbers and sequences,

As we see in Table 1, there are not any big differences between these two courses. We would like to proof if there is a difference between the rates of the longer course and the short one. We used the two sample t-test at

significance level α = 0.05.

The null hypothesis was:

H$_0$: There are not any differences between the score of the quizzes of the two groups.

We calculated the test statistics

$$t = 0,288.$$

The p-value is 0,776. Since this p-value is not less than our significance level α = 0.05, we fail to reject the null hypothesis. We do not have sufficient evidence to say that the scores of the quizzes between these two courses are different.

To compare these results with the results of students from the previous year, we can see in Pasáčková (2022) that the highest success rate in 2021 had the quiz about the linear and quadratic equations and inequations and then the quiz about exponential equations and inequations, and complex numbers. Thus, there is not any big difference this year.

The lowest success rate in 2021 was in quizzes about trigonometric equations and sequences. Thus, as we mentioned above, students had every year problems with trigonometric functions. We can see only difference with the topic sequences, in which were students this year more successful.

Now, we can compare more detailed only quizzes, where was the difference between success rates of two groups more than 10 %. It was in the following five topics, see Table 2. In addition, it is highlighted in which questions were the biggest differences between the success rates.

Table 2: Comparing of success rates of each question in both groups.

Comparing of success rates		success rate of each question					average success rate of the test		difference between success rates
Topic	Type of the course	question nr. 1	question nr. 2	question nr. 3	question nr. 4	question nr. 5			
equations with absolute value	52 hours	48%	73%	70%	47%	52%	58%		11%
	32 hours	41%	72%	50%	50%	20%		47%	
arithmetic sequences	52 hours	25%	32%	19%	60%	44%	36%		23%
	32 hours	50%	53%	40%	67%	88%		59%	
complex numbers	52 hours	40%	50%	33%	68%	73%	53%		20%
	32 hours	57%	57%	86%	80%	86%		73%	
combinatorics	52 hours	80%	33%	77%	8%	50%	50%		15%
	32 hours	73%	36%	33%	30%	0%		34%	
word problems	52 hours	27%	25%	54%	33%	-	35%		13%
	32 hours	38%	23%	25%	0%	-		21%	

The lower success rate had, as in the previous year, open-ended questions. Students were more successful in choosing the right answer from five possibilities. In the entrance exams, there are only closed-ended questions with five possible answers. Some examples of the entrance exams are in Klůfa (2022).

For example, the question nr. 3 of the complex numbers quiz was as follows (Figure 1) and for some of the answers see Figure 2.

Find the imaginary part of the complex number:
$$i^5 - i^{35} + i^{19}(5i - 3)$$

Figure 1: Question nr. 3 of the complex numbers quiz.

Figure 2: Few answers of question nr. 3.

To see some other questions, for example from the sequences, see Pasáčková (2022). Thanks to the feedback from these quizzes the teacher could go back to the problems which were not clear for students.

CONCLUSIONS
We did not find any big differences between the scores of quizzes of the long-term and short-term courses. As we supposed there is not any rule, that there are more clever students in the short-term course. It differs and often it depends when students get known about these courses and if they have enough time to follow these course for few months.

We can conclude with the fact that the preparing courses are for students very beneficial, the proof of it is the very high interest of these courses. Now, there is very high demand on on-line courses primarily between students from the remotely placed places from Prague.

The interactive quizzes are very helpful for teachers as well as students to find out if students understand the topic. Many students after seeing that they are not the only one who do not understand, they do not feel shame and ask and explain what the problem for them in the exercise was.
After finishing the course, students fulfilled the questionnaire about the course. The majority of students found the quizzes very useful and liked them.

REFERENCES
Ananga, P., Biney, I. (2017). Comparing face-to-face and online teaching and learning in higher education, MIER Journal of Educational Studies, Trends and Practices. vol. 7, pp. 165 - 179.
Bozkurt A., Sharma, R. C. (2020). Emergency remote teaching in a time of global crisis due to Corona Virus pandemic, Asian Journal of Distance Education, vol. 15, no. 1, pp. i–iv.
Dhawan, S. (2020). Online learning: A panacea in the time of COVID-19 crisis, Journal of Educational Technology Systems, vol. 49, no. 1, pp. 5-22.
Barry, D. M., Kanematsu, H. (2020). Teaching during the COVID-19 Pandemic, Eric.
Glivická, J. (2020). Comparison of higher education in quantum computing across Europe with special emphasis on the Czech Republic, 12th International Conference on Education and New Learning Technologies. Spain: IATED Academy, pp. 3922-3926.
Glivická, J. (2019). New and Emerging Study Resources as Enrichment and Replacement of Traditional Scheme of Introductory Mathematical Courses in Higher Education. The Turkish Online Journal of Educational Technology, vol. 2, pp. 232 – 238.
Klůfa, J. (2019). Matematika pro bakalářské studium na VŠE, Ekopress, Praha
Klůfa, J. (2022). Matematika k přijímacím zkouškám na bakalářské stadium VŠE, Ekopress, Praha.
Klůfa, J. (2017). Homogeneity of the Test Variants in Entrance Exams. 21st International Conference on Circuits, Systems, Communications and Computers, DOI: 10.1051/matecconf/20171250, pp. 1-4.
Otavová, M., Sýkorová, I. (2016). Differences in results obtained by students of different faculties, Journal on Efficiency and Responsibility in Education and Science, vol. 9, no. 1, DOI: 10.7160/eriesj.2016.090101, pp. 1-6.
Otavová, M., Sýkorová, I. (2020). Matematika - Soubor testů pro všechny kurzy matematiky na VŠE, Ekopress, Praha.
Pal, D.,Vanijja, V., Patra S. (2020). Online Learning During COVID-19: Students' Perception of Multimedia Quality, 11th International Conference on Advances in Information Technology, DOI:10.1145/3406601.3406632.
Pasáčková, J. (2022). Getting students engaged in on-line learning. The Turkish online journal of educational technology. 2022, 21, nr. 2, pp. 39–46.