Getting Students Engaged in On-Line Learning

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ABSTRACT
This paper deals with a course of mathematics at an university in the Czech Republic. This course is for incoming students. It prepares students for math entrance exams. During the coronavirus pandemic period (2020 - 2021) we taught the course online. We had to solve the problem with communication with students and obtain feedback from them. For this reason, we used interactive quizzes. In this article, we compare the situation at other universities, and we introduce online quizzes. Further, we compare their success rate during the course. In addition, we present the results from the student´s course evaluation survey.
Keywords: mathematics, quiz, entrance exam, feedback

INTRODUCTION

There are every year preparing courses for entrance exams at Prague University of Economics and Business (PUEB). Our Department of Mathematics prepare these courses for the mathematics part of exams. Passing these courses increase the possibility of success of students during the entrance exams. All students who want study at PUEB have to pass the entrance exams from Mathematics and other subjects depending on their field of study. Students with excellent school results do not have to pass entrance exams at some faculties of PUEB.

During the study at PUEB, all students have to pass an exam from Mathematics for Economists or Mathematics for Informatics. Thus, importance of entrance exams is justifiable. These courses of Mathematics contain linear algebra and mathematical analysis, as you can see in 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. The contents and examples of final exam can be seen in textbooks Klůfa (2019), 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 Klůfa (2020) discuss the change in the number of questions which was made during last years.

We teach these courses for many years, but this year was the big challenge for us, since the on-line teaching period started. In 2020/2021 we taught whole the academic year online and these preparing courses were online as well. During the lock down as in many other schools, see for example Barry et al. (2020), Pal et al. (2020), was possible to use for teaching the platform MS Teams or Zoom. MS Teams was used at some schools before the pandemic period, but it was not so often, for example Martin et al. (2019). Glivická (2020) described how the transition to online teaching at PUEB was made and the process and problems connected with online teaching. The biggest problem for teachers were 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.
In addition, in Glivická (2019), there are responses of students of our university about the on-line learning and other studying materials and they show that although the majority of students would welcome other study resources then textbooks and use video tutorials during their self-study time, most of them are not familiar with such platforms and projects as edX, Coursera, Khan Academy, or Wolfram Alpha.

There are many articles which compare and describe the problems with the online teaching. We can mention some research from other countries. 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. Equally, we tried not only to teach, but to involve the students and to avoid that they get bored.

The aim of this article is to compare results of students during the courses and to compare which topic was the most problematic for them.

THE ORGANIZATION OF THE COURSE

The courses at PUEB take 52, 40 or 32 hours. Long-term courses start during November or December. Short-term courses start in January or February. For students, who live far from Prague, the courses are taught on Saturday, too.

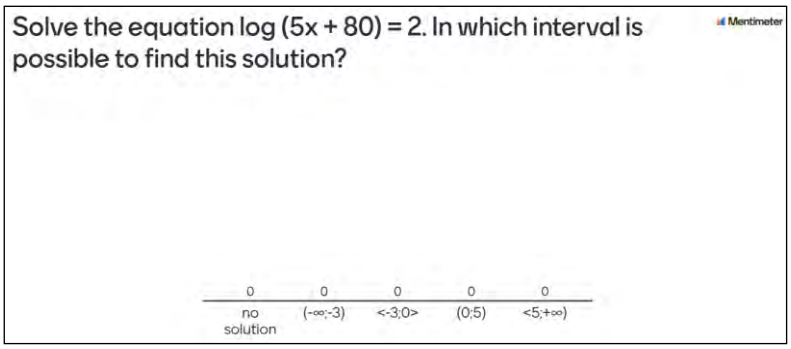
The last academic year was influenced by COVID-19 pandemic and classic face-to-face teaching was converted into online teaching. In this article, we deal with the entrance exam course which takes 40 hours. it started in November 2020 and finished in April 2021. This course was taught in on-line form. It was divided into 20 weeks and every week there was one lesson which takes 2 academic hours. There were 52 students enrolled in the course.

The course 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.

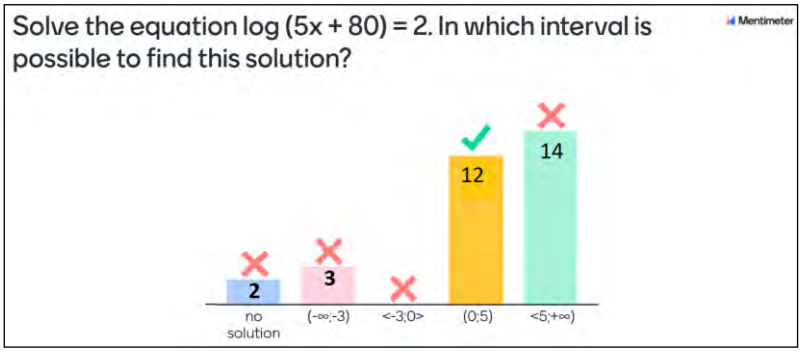
The courses were taught on-line all the time. We used the platform Zoom. Students were following how the teacher solved some examples and then they have the possibility and time to solve some examples themselves.
The problem was with the lack of personal contact when teacher wanted to know if students had understood the topic. Some students did not have problem to ask during a lecture, but many of them did not ask. Thus, we had to use some interactive tools to find out if students understood. We chose interactive quizzes.
At the end of every lecture, we did an interactive quiz. It contained five problems from the discussed topic, and it had a time limit.

We used online interactive real-time voting software Mentimeter to create these tests. Mentimeter is an easy-to-use 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 comparing with other students and if they could be satisfied with 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. Picture 1 is an example of close-ended question.



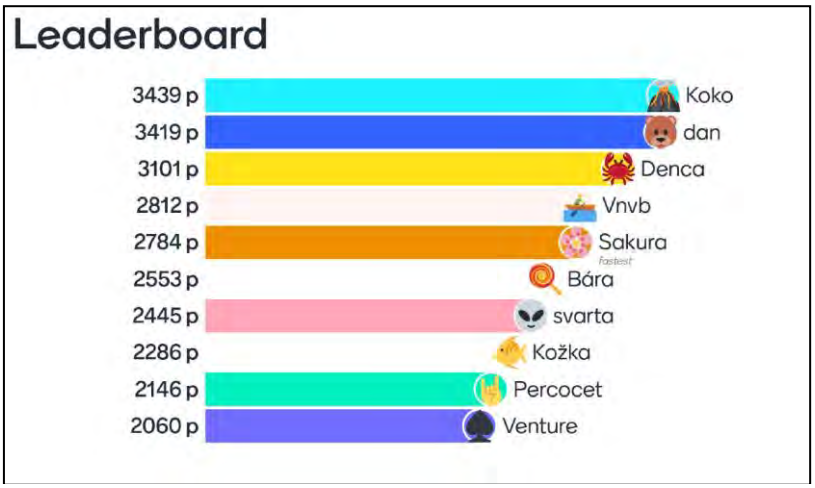
Picture 1: The closed-ended question.

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, see Picture 2.



Picture 2: **Answers** of students.

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. On the teacher´s screen it could be seen only first 10 persons, see Picture 3. The other students saw their ranking only on their mobile phone.



Picture 3: Leaderboard.

EVALUATION OF QUIZZES

Students fulfilled ten quizzes during the course. The success rate of each question (it means how many percent of students wrote the right answer) and the weighted average success rate of all tests is shown in Table 1.

Table 1: The success rate of quizzes.

Topic	success rate of each question					weighted average success rate of the test
	question nr. 1	question nr. 2	question nr. 3	question nr. 4	question nr. 5	
expressions processing	13%	43%	40%	74%	50%	43%
linear and quadratic equations and inequalities	55%	73%	48%	38%	-	54%
systems of linear equations	33%	7%	36%	57%	50%	36%
exponential equations and inequalities	44%	59%	31%	38%	60%	47%
logarithmic equations and inequalities	23%	66%	39%	46%	37%	42%
sequences	10%	6%	50%	30%	50%	32%
trigonometric equations	32%	25%	20%	9%	29%	23%
complex numbers	36%	46%	23%	92%	25%	45%
combinatorics	68%	12%	65%	21%	20%	39%
analytical geometry	27%	38%	33%	31%	50%	36%

Since that only few students asked during the classes when something was not clear, thanks to these tests the teacher found out what kind of examples were not clear for students and when they made the majority of mistakes. The success rate in all tests is not very high, but it is caused by the time limit as well. Some students were more stressed to calculate with the time limit. In addition, some errors were made as typing errors and if a student answered once, it was not possible to change the answer.

The lower success rate had open-ended questions. On the other hand, students were more successful in selecting the right answer from five possibilities. In the entrance exams, there are only closed-ended questions with five possible answers.

Students always obtained by e-mail the right detailed solution of these tests exactly after the class. And the teacher paid attention to the examples, which were the most problematic problems, next class.

If we compare the quizzes, then the highest success rate had the quiz about the linear and quadratic equations and inequations and then the quiz about exponential equations and inequations, and complex numbers. The lowest success rate was in quizzes about trigonometric equations and sequences. The topic trigonometric equations is always one of the most complicated at secondary schools. For example, you can see in Picture 4, questions from the sequences´ quiz.

1) Find a_2 in the following sequence:

$$a_{n+1} = a_n - 0.5a_{n-1}$$

$$a_4 = 6, a_5 = 2$$

2) The sides of right-angled triangle are the first three terms of arithmetic sequence. The hypotenuse is 30 cm. What is the sum of the two others side?

3) Find the first term and a geometric quotient in the following geometric sequence:

$$a_3 + a_4 + a_7 = 5, \qquad a_4 + a_5 + a_8 = 15$$

4) Put two numbers between roots of the equation $x^2 + 5x - 14 = 0$ so that they create together with these roots first four terms of arithmetic sequence. What is the sum of these two numbers?

5) Find the sum of the first five terms of the geometric sequence such that:

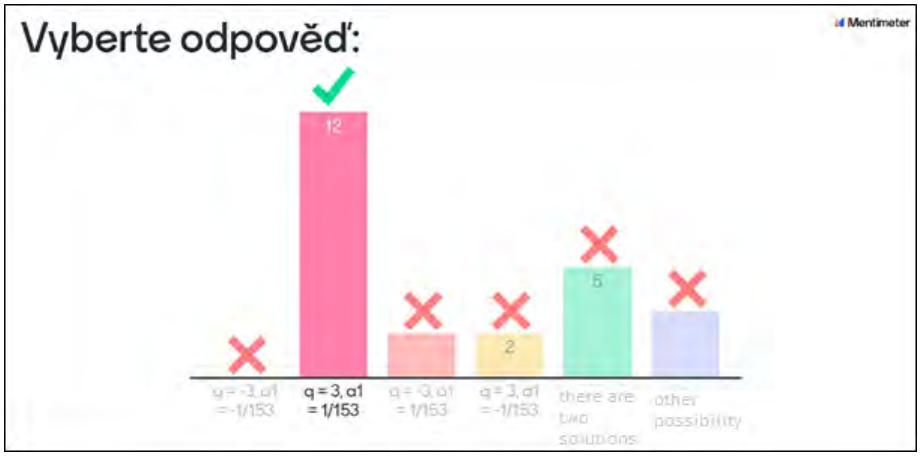
$$a_1 = \frac{1}{8}, \quad a_4 = 1$$

Picture 4: The **sequences** quiz.

The answers of questions 1, 2 and 4 was the number and questions 3 and 5 were closed-ended questions. The answers of students you can see below (Picture 5 - 9). The closed-ended questions had the higher success rate than the open-ended. The biggest problem for students was the second question, where only one student knew the right answer, an in the first question only two students. The reason was that for students is hard to understand to a recurrent sequence (problem 1) and to apply, in addition, Pythagorean theorem (problem 2).

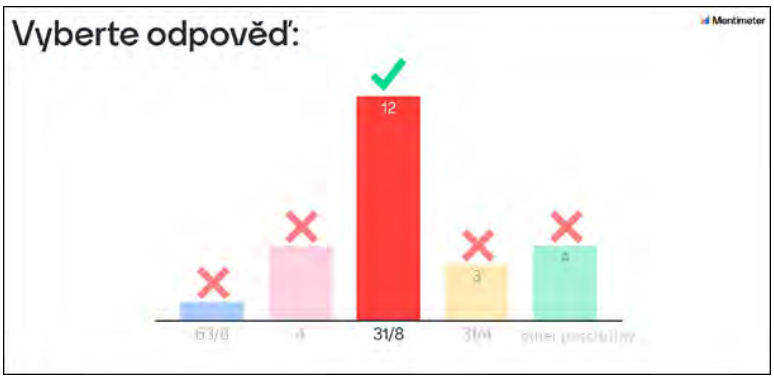
Picture 5: Answer to the first question.

Picture 6: Answer to the second question.



Picture 7: Answer to the third question.

Picture 8: Answer to the fourth question.



Picture 9: Answer to the fifth question.

Thanks to feedback from these quizzes the teacher could go back to the problems which were not clear for students. After other practicing students wrote again new quizzes of these topics. The new quiz about goniometric equations has the success rate 47 % and the sequences´ quiz has the success rate 50 %.

EVALUATION OF THE COURSE

Students fulfilled the questionnaire after passing the course. The rate of return was not high. We obtained responses from 26 students from the total 52. The majority of students (22 from 26) who fulfilled the questionnaire were students who missed maximum 3 classes. The average absence of students was 6 from 20 classes. 32 students have less than 6 absences. Some students attended only few classes because they wanted to study only some topics or since they do not prefer this online form.

Half of the students answered they preferred the on-line course than classis learning at school. The other half of students answered that they cannot focus on the topic only by watching.

Twenty students were admitted to university. The half of them passed the entrance exams and the second half had

the excellent results on the secondary school, thus did not have to pass the exams on some faculties. Many of students attended the course to get prepared not only at the entrance exams but to prepare for secondary school-leaving exam.

Students who passed the exams (19 persons) claimed that there were problems which they learnt during the course. The biggest problem was for all of them the word problems. Then students mentioned they had problems with geometric equations, combinatorics, analytic geometry, exponential and logarithmic equations.

Students evaluated positively all the course and the quizzes. They found it very useful to calculate with the time interval and to see their ranking between other students.

PREPARING COURSES AT OTHER CZECH UNIVERSITIES

We do not take it for granted that university provided these courses. There are only few universities in the Czech Republic, where it is possible. Some courses are free of charge, some are paid. Courses at PUEB are long-term, they take two and more months and they are paid.

For example, at the College of Polytechnics Jihlava (CPJ) they provide these courses for free and they are short-term, usually they take less than one month. Courses at CPJ are for the incoming students, but not to prepare for the entrance exams. The majority of students of study programs at CPJ are accepted without entrance exams. This causes a problem, that many students do not have the necessary level of knowledge and therefore they are obliged to pass a test at the first lesson of Mathematics. Students who did not pass this test with the score more than 50% cannot study the subject Mathematics and repeat it next semester. Thus, these courses at CPJ are for students who are not sure about their knowledge from a secondary school and who want to prepare for this first test. The results of these courses at CPJ can be seen in Dvořáková a Kotoučková (2019). In Pasáčková (2019, 2021) these courses are evaluated as well as their impact on results of students in Mathematics.

At another Czech university, Masaryk University, they have the same procedure as at CPJ. Students are obliged to pass an “Entrance test to Mathematics” and after that they can study the subject Mathematics.

Entrance exams at PUEB have the form of test. Students can choose one answer from five possibilities. The test have 15 problems and contains the basic topics from the secondary school. Students are not obliged to use a calculator nor mathematics table. But they have a list with the elementary formulas. The example of entrance exams can be found in Klůfa (2022). It is observed the complexity of entrance exams every year and the evaluation of these tests can be seen, for example in Klůfa (2017), Otavová et al. (2016).

CONCLUSIONS

The preparing courses are for students very beneficial, the proof of it is the very high interest of these courses. In this academic year (2021/2022) we offer on-line courses as well as classic courses at university. There is very high demand on on-line courses between students from the remotely placed places from Prague. Thus, we do not have now courses at university on Saturday for these students, but we have only on-line courses during the weekdays. 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.

Now, we applied the new experiences with on-line teaching, not only in these courses but during the classic teaching hours as well. We use the on-line quizzes during the classes to find out if students really understand the topic and if they remember the important parts of the lesson.

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