DOI: https://doi.org/10.31410/ERAZ.S.P.2021.129

Digital Methods of Education and the Level of Students' Knowledge in Mathematics

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Keywords:
Digital methods of education;
Distance learning;
Mathematics teaching;
Knowledge evaluation;
Z-test

Abstract: *The global pandemic caused by the COVID-19 disease significantly affected higher education in 2020 and resulted in the transition from full-time to distance learning. The question here is the effectiveness of the implementation of new methods of online teaching and learning in relation to the quality of students' knowledge. The main goal is to analyze the mathematical knowledge and skills of students and compare the study results in Mathematics in the academic years 2018-2020 in the context of full-time teaching versus online teaching. The paper also points at the possibilities of teaching and studying mathematics using various tools and methods of digital education, e.g. LMS MOODLE, MS TEAMS and MS FORMS. The research sample consisted of students of the Faculty of Engineering and research data were retrieved from prelim tests, exam tests and final grades in mathematics exams and then were analyzed by selected methods of quantitative and qualitative research.*

1. INTRODUCTION

The paper presents the results of pedagogical research focused on the evaluation of educational outcomes in mathematics and the level of students' knowledge acquired with the support of information technology. Distance education allows using active and passive methods of education. Active methods include online lectures and video conferences with direct participation of teachers and students. Passive teaching methods include self-study of professional literature, uploaded presentations and elaboration of seminar papers. The situation caused by the COVID-19 pandemic required the use of detailed electronic study materials in the process of education.

At the Slovak University of Agriculture in Nitra, mathematical subjects in various study programs are focused on selected topics from mathematical analysis, algebra and statistics. Students will use the acquired math knowledge in various subjects of study.

According to Drijvers (2015), teachers, educators and researchers are confronted with many issues in the integration of digital technologies. D'Ambrosio and Borba (2010) study the interaction and formation between ICT and other trends in mathematics teaching. Borba et al. (2017) identify important development trends that also affect mathematics education: mobile technologies, large-scale open online courses (MOOCs), digital libraries and object design, co-learning through digital technologies and teacher education through blended learning. Rumanová and Drábeková (2019) deal with visualization of mathematics theme and their use in the educational process. Moreno-Guerrero et al. (2020) state the e-learning method has increased its use and application in

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teaching and learning processes during the spread of the COVID-19 pandemic. Pechočiak (2020) states „The coronavirus crisis forced us and taught us to make changes in education. We led the teaching process in other, distance ways. We have developed a number of new digital teaching aids, lectures and instructions for practicing their curriculum“ (p. 52). Drábeková et al. (2018) consider that „The Slovak University of Agriculture in Nitra with its educational, scientific and research activities represents the significant part of a European and world educational area. It has become a modern open university which reflects current needs in agri-food sector in a local and global scale“ (p. 23). As noted by Horská et al. (2015), universities search for possibilities to attract students, to offer them education of high quality and to bring value added and differentiation to the university education. Pechočiak and Kecskés (2016) state „The role of educational institutions in university graduates training in new global space is indisputable“ (p. 668). According to Košovská et al. (2020), mathematics as a part of university studies represents an enemy for most students and it is necessary to make it accessible and more attractive. According to Hudáková and Papcunová (2015), „students would need to focus more on practical skills than knowledge, and then modern and activating teaching methods could be applied to schools“ (p. 516). Sánchez-Guerrero et al. (2019) state that mathematics courses are the basis of engineering studies for engineering students and are necessary for mastering further engineering studies.

2. MATERIAL AND METHODS

The basic tool for a student and teacher in digital education is a laptop, tablet, computer, mobile phone, or other digital devices. This device will never replace a teacher, textbook or other teaching aids. Learning is a psycho-physiological process that can be supported by information and communication technologies, but cannot be replaced. Therefore, the digitization of education brings both content and qualitative changes. It enables simulation of the real environment, individual study pace, choice of place and time for study, reduces the fear of failure.

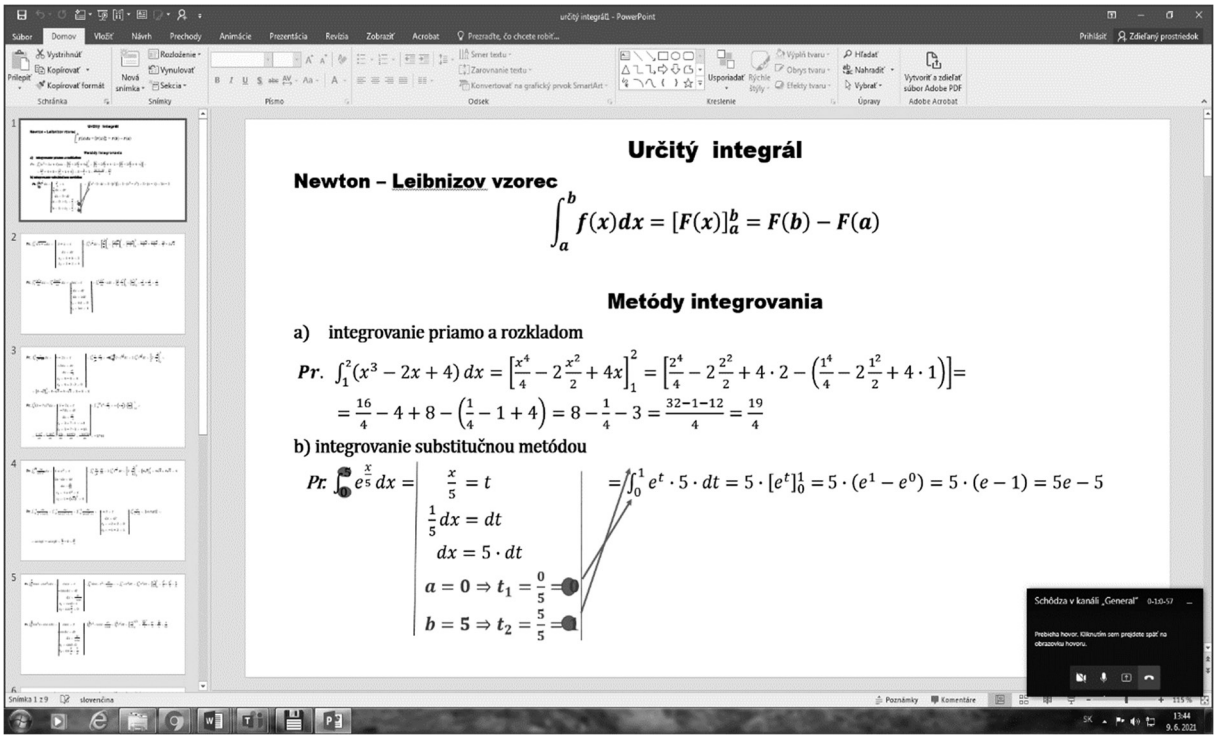

Figure 1. Online teaching: The topic of a definite integral

Source: Authors

Digital tools are useful in teaching and learning. However, education is not just about access to digital devices; it requires an integrated approach taking into account the psychological, social, pedagogical and practical requirements of teaching and learning. Online lectures and exercises belong to the important aspects of e-learning, ensuring immediate "live" interaction between the teacher and a group of students. The online activity should primarily focus on sharing the volume of information as quickly as possible, requiring detailed preparation, a pre-determined and agreed course, as well as the appropriate technical equipment of the individual participants. The teacher becomes a moderator of student-led discussions and at the same time fulfills an organizational, social and intellectual role. The easiest way for group communication between students and teachers is supported by Microsoft Teams. Using this application, online exercises and lectures were held, while the teacher shared lectures created in PowerPoint. In teaching in the online environment, the interaction of students focused mainly on the prepared materials and teamwork. Figure 1 presents a sample from the online exercise in the subject Mathematics for technicians in MS Teams, teaching a definite integral.

Another educational platform that provides teachers and students with an integrated education system is LMS Moodle. It is used in distance learning, but also as a support for full-time education. In this system, we created courses for the subject Mathematics, but also for study groups individually. As part of online courses, we added current lectures, study materials and downloadable materials. Students can print them out and record observations and details. If the student has the content of the exercise in front of him, he can progress at individual speed and can discuss the topic. However, all electronic materials should receive feedback from students in the form of tests, questions, etc., so some teachers created assignments for students, which were evaluated during the semester.

Student assessment was effectively done using Microsoft Forms, which has built-in support for math and formulas. We used a quiz to create and evaluate mathematical tests, as we can assign points to individual assignments, insert mathematical formulas, give instructions, define the correct answers. Test characteristics are defined in the test settings, such as who can fill in the test, automatic display of results for students, entering the beginning and end of the test, random order of questions and more.

3. RESULTS AND DISCUSSION

The digital teaching methods mentioned in the previous sections have been applied as basic criteria for verifying the increase in the effectiveness of mathematics teaching by applying digital methods. Based on this, the research goals were set:

- finding out the level of students' knowledge in selected mathematical topics of the students of the Faculty of Engineering of SUA in Nitra,
- finding out the differences in study results in the subject Mathematics for Technicians between three different samples of students.

In formulating the research hypotheses, we relied on theoretical knowledge on this issue, on the experience based on our pedagogical practice. We want to verify the main hypothesis: By implementing digital methods, we will increase the level of knowledge of students. The input data determined the level of knowledge of mathematics in students in the years 2019 - 2021. Tests from exams in the summer semester in the subject Mathematics for technicians were evaluated, which were obtained in three samples of students:

Year 2019 (60 students) - tests from exams in the summer semester of school year 2018/19, Year 2020 (73 students) - tests from exams in the summer semester of school year 2019/20, Year 2021 (53 students) - tests from exams in the summer semester of school year 2020/21.

In groups 2020 and 2021, students used the digital methods listed in the Material and Methods section. The test was written by students who registered for the exam in the subject Mathematics for Technicians; the time for elaboration was 90 minutes. The test was assigned to students via MS FORMS.

The exam test contained 5 tasks with the following thematic content:
Task 1: identifying the domain of a function,
Task 2: application of the derivative of a function with one real variable,
Task 3: definite integral – the area of a planar shape,
Task 4: differential equation,
Task 5: theoretical questions.

For the correct solution of each task there were 10 points and 5 theoretical questions, each for 2 points.

Figure 2 shows an example of two tasks from the test (presented in Slovak). In problem number 4, students counted the content of the shape bounded by the function and the x-axis. In task 5, they answered the question of how the monotonicity of a function changes at a point of local maximum.

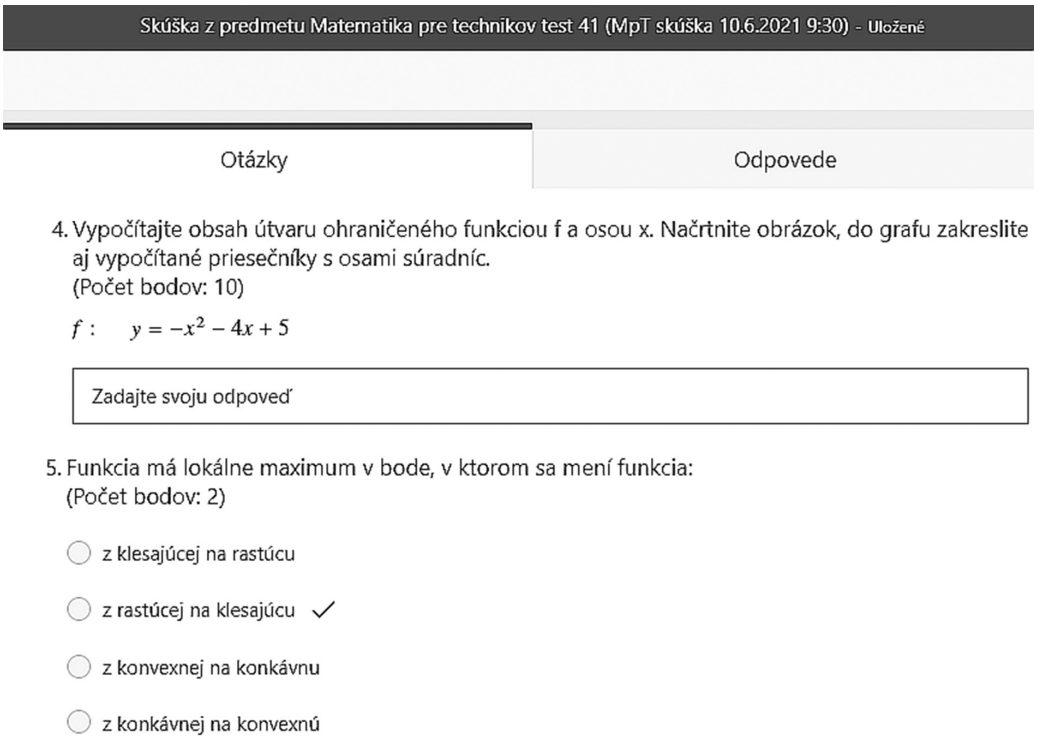

Figure 2. Demonstration of two tasks from the exam test
Source: Authors

Using MS FORMS tools, we can evaluate students' answers. In Figure 3 is presented an evaluation of the theoretical question about the concavity of a function: If all points of the graph of the function *f* lie above tangents constructed at any point from the interval (a, b), then the function is on this interval (1 b.): a) increasing, b) decreasing, c) concave up, d) concave down.

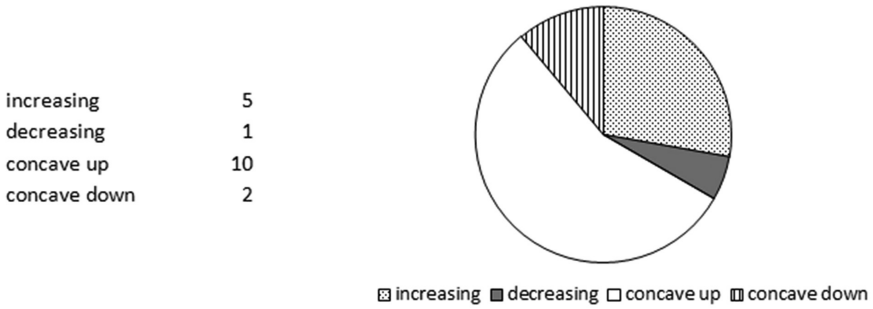

Figure 3. Evaluation of answers to a theoretical question

Source: Authors

In the answers, we see that 56% of students answered correctly (option c) and 44% of students gave an incorrect answer.

In the individual years 2019 to 2021, we evaluated the tasks from the exam test and compared the success of students in percentages. Figure 4 shows the results and we see that in 2020 there was a decrease in the level of knowledge compared to 2019 in the topic of application of derivation (Task 2). We recorded the largest increase in points in theoretical questions in 2021 compared to previous years (Task 5). This means that students used digital methods and electronic materials in their studies, which were supplemented in 2021 by other topics.

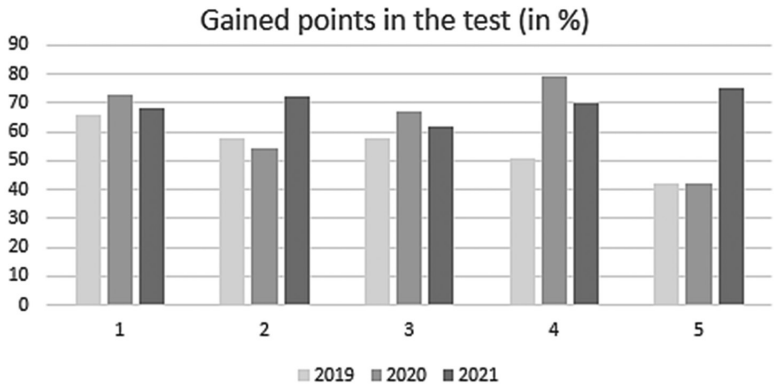

Figure 4. Evaluation of individual tasks from the exam test by year

Source: Authors

Using the *z*-test, we will test the null hypothesis, which states that the level of knowledge of students is the same, in contrast to the alternative hypothesis. There is a test problem of null hypothesis $H_0 : \mu_1 = \mu_2$ against alternative hypothesis $H_0 : \mu_1 \neq \mu_2$.

Table 1. Results of z-test

	2019 and 2021		2019 and 2020		2020 and 2021	
Mean	33.87	27.8	31.19	27.8	33.87	31.19
Variance	293.963	88.976	185.157	88.976	293.963	185.157
Observations	53	60	73	60	53	73
z Stat	2.289		1.692		0.941	
z Critical one-tail	1.960		1.645		1.645	

Source: Authors

In Table 1 we see that the value of the *z*-test is 2.289 for the years 2019 and 2021, the critical value is 1.960 at the level of significance $\alpha = 0.025$. For the years 2019 and 2020, the value of the

z-test is 1.692, the critical value is 1.645 at the level of significance $\alpha = 0.025$. Since the value of the *z*-test in these two cases is greater than the critical value, we reject the null hypothesis. This means that we accept an alternative hypothesis: the average level of students' knowledge is significantly different in these groups.

If we compare the years 2020 and 2021 (Table 1), the value of the *z*-test is 0.941 and the critical value is 1.645 at the selected level of significance $\alpha = 0.025$. Since the value of the z-test is less than the critical value, we do not reject the null hypothesis, which states that the level of knowledge of students is the same in the evaluated groups.

4. FUTURE RESEARCH DIRECTIONS

The analysis of study results in MS FORMS could help teachers focus on topics that have been mastered by students the least. The research has shown that MS FORMS can be used for feedback as well as for conducting surveys. The aim of the implementation of digital methods in education is an improvement of the average mark in mathematical subjects. Further research will be aimed at comparing the results of other tasks, identifying the main problems and causes of errors and then proposing ways to eliminate students' errors.

5. CONCLUSION

The pandemic, in addition to major problems, also brought a significant shift in education. It has accelerated the digitization of the educational process, shifting digitization to other areas of life. The way teachers and students work is modernized and changed during teaching with the support of digital resources. It influences educational competencies in such a way that it is necessary to redesign the content, methods and forms of university education. In the paper we tested the hypothesis that digital methods help to increase the level of students' knowledge. Based on results of z-test we can state that methods of digital education have brought positive results and confirmed the improvement of study outputs in Mathematics.

We assume that the benefit of using digital methods will be the development of mathematical skills and thinking of students. We emphasize independent work, activity and application of knowledge from mathematical subjects in practice. When increasing the effectiveness of education, feedback is also important to identify students' problems and find ways to eliminate them. Teachers aim to increase the level of knowledge of students and the quality of the educational process. Obtained research results will serve as the basis for the innovation of mathematical education in the process of digitization of university studies.

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