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UNIVERSITY STUDENTS' ATTITUDES ABOUT ONLINE MATHEMATICS TEACHING DURING THE PANDEMIC[**1]

Abstract: The COVID-19 pandemic forced universities all over the world to shift from face-to-face to online education. Teaching and learning mathematics online bring many challenges for teachers due to its heavily symbolic and diagrammatic nature. The aim of the study was to determine whether it is possible to achieve good quality of university students' work and effectiveness of teaching by organizing online mathematics classes at non-mathematical faculties in the Republic of Serbia. The research focused on exploring students' views of online

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mathematics teaching, considering the influence of educational-scientific fields of their study programs and self-assessed level of mathematical knowledge. The study was conducted among undergraduate students (N = 224) of seven faculties/ departments of three state universities and one private university in 2022. Both quantitative and qualitative methods were used for data analysis. The research results point to the conclusion that undergraduate students from our sample generally did not express positive attitudes towards online mathematics classes. Also, their attitudes were determined by the educational-scientific fields of the study programs they studied, as well as by their self-assessment of mathematical knowledge. Such results can be a significant starting point for new research on the quality and effectiveness of teaching, which should includeuniversity teachers who organized online mathematics classes.

Keywords: *online mathematics teaching*, *university students' attittudes*, *educational-scientific field*, *COVID-19*.

Introduction

In March 2020, the World Health Organization declared the outbreak of the COVID-19 pandemic all over the world (WHO, 2020). This resulted in many countries introducing strict physical or social distance measures such as workplace and school closures and travel bans in order to prevent the spreading of the virus. According to UNESCO, more than 90% of the world's student population was affected by school and university closures (Commodari, Rosa, Coniglio, Conti, 2022). In order to ensure teaching and learning continuity, universities and schools were forced to shift from face-to-face to online education (Jevtić, 2021). Before the COVID-19 outbreak many universities all over the world were not accustomed to distance and online learning (Coman, Țîru, Meseșan-Schmitz, Stanciu, Bularca, 2020; Cicha, Rizun, Rutecka, Strzelecki, 2021). The Republic of Serbia is not an exception, since online learning was a complementary form of education used only at some universities (Mihajlović, Vulović, Maričić, 2021). Both teaching staff and students faced numerous challenges and had to adapt to courses held fully online (Bonsangue & Clinkenbeard, 2021; Casinillo, Casinilo, Valenzona, Almonite, Valenzona, 2021). Teaching in online learning environments requires different pedagogical approaches, practices and abilities in comparison to teaching in face-to-face settings (Gurley, 2018). The quality of instruction in online learning courses might be affected by the readiness of teachers to teach in these settings (Fakhrunisa & Prabawanto, 2020). The sudden shift to online settings due to the pandemic put many teachers in the position to use digital tools and e-platforms which they had never used before. However, choosing adequate tools, materials and resources for teaching and learning in online settings is a tedious task even in non-pandemic conditions, and it frequently ends up with teachers adapting and using traditional instructional strategies and pedagogies in online environments (Raza & Reddy, 2021).

Theoretical Background

Mathematics as a subject is considered to be challenging for students and difficult to comprehend even in normal (non-pandemic) conditions (Almarashdi & Jarrah, 2021; Fritz, Haase, Räsänen, 2019, Raza & Reddy, 2021). Since students face many difficulties in face-to-face settings, it seems unlikely to expect that they will easily adapt to learning mathematics in online environments. Teaching and learning mathematics online bring many challenges for teachers due to its heavily symbolic and diagrammatic nature (Cassibba et al., 2021; Engelbrecht & Harding, 2005; Ní Fhloinn & Fitzmaurice, 2021; Trenholm & Peschke, 2020). Due to the sudden pandemic outbreak many teachers did not have time and opportunities to go through some rigorous training about online and distance learning, which made it difficult for them to discuss and present equations, formulas and symbols using mathematical notations in online settings (Casinillo et al., 2021).

Mathematics, as one of the most abstract conceptual systems, involves a lot of cognitive metaphors which play an essential role in bringing many mathematical concepts into being (Alibali & Nathan, 2012; Núñez, 2008). Since mathematics is made of abstract objects which cannot be touched, the use of metaphors is required so that learners could objectify and understand mathematical topics (Cassibba et al., 2021). It is crucial that teachers, when applying metaphors, make use of their bodies and gestures in conjunction with formal mathematical language in order to help students visualize new mathematical objects in terms of those they are already familiar with (Cassibba et al., 2021; Núñez, 2008). One example of the metaphorical use of gestures is when teachers use hand gestures to depict the graphical representation of an algebraic function and describe its monotonicity. Another instance occurs when teachers extend their hands outward to demonstrate how a graph approaches but never touches an asymptote, effectively mimicking the idea of 'reaching for something just out of grasp'. At the elementary level, teachers commonly use gestures when explaining basic arithmetic operations (addition, subtraction). Moreover, many nonverbal aspects of communication (facial expressions, gestural movements, posture, eye-contact, etc.) are important for teachers since they suggest whether the students understand the content or it is needed to adjust and modify the lesson (Breda, Farsani, Miarka, 2020; Zeki, 2009). Face-to-face interactions between teachers and students open up opportunities for teachers to give instant feedback and to address students' misconceptions and misunderstandings (Chirinda, Ndlovu, Spangenberg, 2022). Busto, Dumbser and Gaburro indicate that a mathematics lecture represents dynamic and creative process which requires the physical presence of audience so that the teacher "can instantaneously fine-tune the evolution of the lecture according to his/her perception of the level of attention and the facial expressions of the students, in addition to the questions asked and the comments made by the students" (2021: 2). In transition from face-to-face to online education, nonverbal aspects of teaching

mathematics were significantly reduced (Aldon, Cusi, Schacht, Swidan, 2021; Cassibba et al., 2021). Some studies point out that students prefer when they can see their teachers' gestures and facial expressions during mathematics instruction to when they cannot do it (Busto et al., 2021; Chirinda et al., 2022).

Among other obstacles and challenges, mathematics teachers and students also reported that they experienced difficulties such as limitations in communication and problems with internet connection (Casinillo et al., 2021; Ní Fhloinn & Fitzmaurice, 2021). Some studies indicate that students also faced difficulties in comprehending their learning modules and online materials, as well as assessment activities, and encountered problems such as overload of assignments, lack of interaction (both between learners and learners and teachers) and proper guidance from their teachers, and having to take more responsibility for their own learning (Amelia, Kadarisma, Fitriani, Ahmadi, 2020; Borges & Costa, 2022; Casinillo et al., 2021; Noviani, 2021; Radmehr & Goodchild, 2021). Busto et al. (2021) point out that students, especially freshmen, should have at least a minimum level of direct interaction with each other and that it is possible to realize this through the implementation of blended teaching of mathematics.

Although online teaching and learning have some features which are not present in face-to-face settings, basic principles of teaching and learning mathematics should be applied in online environments (Engelbrecht & Harding, 2005; Radmehr & Goodchild, 2021). Engelbrecht and Harding point out that there should be "a sound balance between teacher and learner-centered activities" (2005: 254). They further indicate that special attention should be given to planning interaction between, for example, learner and content, learner and instructor and between learners. Although each of these forms of interaction is significant, Tanis (2020) reports that in online learning environments, the interaction with teachers was more valued than the one with other students and course content. Maintaining regular communication between teachers and students can be very effective, since it might help in supporting learning and decreasing anxiety (Radmehr & Goodchild, 2021). Noviani (2021) argues that the reason why some students do not understand the mathematical content taught through online instruction might be the difficulty of communicating with students using mathematical language such aslimitations of writing mathematical symbols. Further, he suggests that in order to overcome these difficulties teachers should encourage more interaction and online discussions. Teachers should cultivate students' interest in mathematics by providing real-life examples and activities during online teaching (Casinillo et al., 2021). Furthermore, it is important to create opportunities for students to develop a relational understanding of mathematics in online learning environments (Radmehr & Goodchild, 2021).

Raza and Reddy (2021) indicate that course engagement and interaction in mathematics courses are positively related to the quality of online education and students' final achievement. They stress the importance of including interactive and engaging activities during online mathematics courses in order to encourage and

support students' engagement and sense of community. Furthermore, authors point out that regular and frequent integration of active assessment strategies such as weekly quizzes and discussion forums, could result in a more engaging and academically rich online learning environment. Using content-centered technologies such as Geogebra, Desmos, and MATLAB can make online mathematics teaching more engaging (Radmehr & Goodchild, 2021).

Some studies report positive effects of learning mathematics in online settings. Ahn and Edwin (2018) developed a mathematical e-learning model based on the learning theories of social constructivism, social realism and connectivity, which made learning mathematics more interesting, meaningful, and applicable to university students. Moreno-Guerrero, Aznar-Diaz, Caceres-Reche and Alonso-Garcia (2020) investigated effects of e-learning method in teaching mathematics to adults attending high school. The authors indicated that the e-learning method combined with weekly face-to-face meetings (in group and individually) positively influenced learners' motivation, participation, autonomy and grades. However, what must not be neglected is the fact that the mentioned courses were carefully planned and designed before being introduced to students, and that teachers were familiar with all the tools. On the other hand, the majority of online mathematics courses that took place during the pandemic outbreak represented an immediate response to the new conditions not leaving enough time for teachers to plan and design activities, assessment, teaching and learning materials.

At Serbian universities, traditionally, mathematics courses in face-to-face settings are taught by chalk and blackboard. This means that teachers write mathematical expressions, formulas and proofs on boards using mathematical notations and symbols (Trenholm & Peschke, 2020). Online mode of teaching was used only as complementary form of education at some Serbian universities and faculties (Mihajlović, Vulović, Maričić, 2021), which made the transition to online and distance learning a real challenge both for students and university staff.

Since there were no previous studies that focused on teaching mathematics at tertiary level in the Republic of Serbia during the COVID-19 pandemic, we believe that our research will contribute to expanding the existing body of literature. This research was conducted in the Republic of Serbia at the time of COVID-19 pandemic and focused on investigating quality and effectiveness of online teaching of mathematics.

Research Methodology

The subject of our research is the quality and effectiveness of mathematics teaching implemented in an online environment during the COVID-19 pandemic at higher education institutions in the Republic of Serbia. The goal of the research is to determine whether it is possible to achieve a good quality of student work and the effectiveness of teaching by organizing online mathematics classes at non-mathematical faculties.

Based on the aim of the research, the following research tasks were defined:

(1) to investigate students' views about the quality and effectiveness of online mathematics teaching in general and their experiences during COVID-19;

(2) to investigate whether students' attitudes and experiences are determined by the educational-scientific field of the study program;

(3) to investigate whether students' attitudes and experiences are determined by the self-assessed mathematics knowledge level.

Sample. The research was carried out in 2022. The research sample included a total of 224 students of undergraduate academic studies of six faculties at three state universities and one private university in the Republic of Serbia: Faculty of Technical Sciences in Čačak, University of Kragujevac; Faculty of Education in Jagodina, University of Kragujevac; Faculty of Education in Sombor, University of Novi Sad; Department of Technical Sciences, State University of Novi Pazar; Department of Natural Sciences, State University of Novi Pazar; and Faculty of Information Technology in Niš, Belgrade Metropolitan University. The selected faculties were chosen because their students had the opportunity to attend mathematics instruction both online (during the COVID-19 pandemic) and subsequently in person. All students were classified into three categories based on educational-scientific field, i.e. the study programs they attend: Social Studies & Humanities (SS&H), Natural Sciences & Mathematics (NS&M), and Technical and Technological Sciences (TTS). This categorization was in compliance with the classification given by the *National Council for Higher Education* (Pravilnik o listi stručnih, akademskih i naučnih naziva, 2017) in the Republic of Serbia. The structure of the sample in relation to the educational-scientific field (ESF) to which the study program belongs is shown in Table 1.

Table 1. Structure of the sample based on the ESF of the study program

	SS&H	TTS	NS&M
f	87	68	69
%	38.8	30.4	30.8

By comparing the content, before the research was carried out, it was determined that the study programs of the faculties belonging to the field of social-humanistic sciences (SS&H) include significantly simpler mathematical content compared to those studied at the faculties in the field of technical-technological (TTS) and natural-mathematical (NS&M) science. This is expected because faculties in the field of TTS and NS&M fields are required to equip students for the functional application of acquired mathematical knowledge in TTS and NS&M fields and in practice. On the other hand, the students of the SS&H field (pre-service primary and kindergarten teachers), who participated in this research, are being prepared to teach mathematics in the lower grades of elementary school, which means that the focus of the mathematics study program is on the acquisition of elementary and basic mathematical knowledge.

For the sake of comparison, the students of the mentioned faculty of the SS&H field study the following mathematical content: some elements of mathematical logic, algebraic structures, matrices, determinants, systems of linear equations, number theory and Euclidean geometry. On the other hand, students in the TTS and NS&M fields study mathematical logic, linear algebra, analytical geometry, mathematical analysis, calculus, differential equations, probability and statistics, etc.

All students were also classified into three categories according to how they assessed their own mathematical knowledge. They were asked, by using a three-point scale, to assess the level of their previous mathematical knowledge (weak, average, advanced). The structure of the sample in relation to the level of self-assessed mathematical knowledge (MKL) is given in Table 2.

Table 2. Structure of the sample in regard to the self-assessed level of mathematical knowledge (MKL)

	Weak	Average	Advanced
f	37	118	69
%	16.5	52.7	30.8

All students who participated in the research had experience in both online mathematics teaching and learning and classroom mathematics teaching and learning, since, at one point in time, all faculties switched to live teaching due to the improvement of the epidemic situation. This very fact allowed students to compare and see the advantages and disadvantages of both types of teaching and learning.

The instrument used was a questionnaire which consisted of two parts. In the first part, background information about students was collected (information about the study program and self-reported mathematics knowledge level). The second part of the questionnaire consisted of two scales, General Attitudes towards Online

Mathematics Teaching Scale (GATOM) and Online Mathematics Teaching Experience Scale (OMTE).

The GATOM scale contained 7 and OMTE scale contained 11 five-point Likert-type items. Both GATOM and OMTE scales were developed by the authors and the items were constructed in accordance with results and implications of some previous studies (Borges & Costa, 2022; Busto et al., 2021; Casinilo et al., 2021; Chirinda et al., 2022; Noviani, 2021; Radmehr & Goodchild, 2021).

Students expressed their views on online mathematics teaching in general in relation to statements about the quality and durability of acquired mathematical knowledge, achievement of learning outcomes, use of digital materials for learning, motivation for learning, maintaining concentration and attention during classes, ability for critical and logical thinking, and communication with the teacher (Table 3).

Table 3. General Attitudes toward Online Mathematics Teaching Scale (GATOM) items

Item code	Item
A1	Online mathematics teaching is just as effective as traditional classroom teaching.
A2	Students acquire better and more permanent mathematical knowledge with online mathematics teaching.
A3	Online mathematics teaching provide more opportunities for students to develop critical and logical thinking.
A4	Effective learning outcomes can be achieved equally with online teaching and with traditional mathematics teaching.
A5*	Mathematics is not a subject that can be taught online.
A6	Communication between students and the teacher during online mathematics classes is better than during live classes.
A7*	Following online mathematics classes requires a higher degree of concentration and attention from students than online classes of other subjects.

Items marked with * were negatively worded and were recoded

When it comes to their own experience with online mathematics teaching, students expressed their views in relation to the level of understanding of mathematical contents presented in the online environment, their own activity in classes, their level of effort and engagement, motivation, concentration, ICT skills and the use of digital materials for learning (Table 4).

Table 4. Online Mathematics Teaching Experience Scale (OMTE) items

Item code	Item
E1	I am satisfied with my participation in online mathematics classes during the COVID-19 pandemic.
E2*	I have difficulty learning mathematics when it is done in an online environment.
E3*	I have difficulties in using the digital material for learning mathematics prepared by the teacher.
E4*	I have difficulty concentrating when mathematics is taught via videoconferencing.
E5	I have the necessary ICT skills to participate in online classes.
E6	I have the same level of motivation to participate in both online mathematics classes and in traditional live classroom classes.
E7	I am more active in online mathematics classes than in live classes.
E8	It is easier for me to follow what the teacher is doing in online mathematics classes than in traditional classes.
E9	I understand mathematics content better during online mathematics classes.
E10*	I would be more active to do mathematics tasks in class if we had live classes.
E11	If I had the possibility to choose, I would choose to attend online mathematics classes instead of traditional classes.

Items marked with * were negatively worded and were recoded

The Cronbach's alpha reliability coefficient for each of the scales revealed acceptable reliability: OMTE ($\alpha = .829$), GATOM ($\alpha = .796$). The statistical analyses were conducted by using SPSS for Windows, version 23.0. For statistical analysis, p values lower than 0.05 were considered statistically significant. The normality of data was evaluated with the use of the Kolmogorov-Smirnov and Shapiro-Wilk test of normality. For the quantitative analyses of data descriptive statistics methods were used (frequency, percentage, mean, standard deviation, mean ranks) and Kruskal-Wallis H test with Dunn post hoc for non-parametric variables. The independent variables in the data analysis were the educational-scientific field and self-assessed level of mathematical knowledge.

Results and Discussion

In order to investigate attitudes about online mathematics teaching and experience during the COVID-19 pandemic, the participants were asked to rate the level of agreement/disagreement with the items in two scales. Table 5 displays the descriptive statistics (means and standard deviations) for the items and for the scales in general.

Table 5. Descriptive statistics for GATOM and OMTE scales

Scale	Item	M	SD
GATOM	A1	2.30	1.21
	A2	2.13	1.09
	A3	2.37	1.13
	A4	2.50	1.21
	A5*	2.46	1.34
	A6	2.27	1.10
	A7*	2.35	1.11
	GA	2.34	.79
OMTE	E1	3.38	1.21
	E2	2.94	1.25
	E3	3.78	1.10
	E4	2.90	1.30
	E5	3.68	1.05
	E6	2.50	1.27
	E7	2.17	1.10
	E8	2.08	1.12
	E9	2.07	1.00
	E10	2.25	1.05
	E11	1.96	1.30
	OE	2.70	.71

According to Narli (2010), [1.00–1.80) indicates a very low level of agreement, [1.80–2.60) indicates a low level, [2.60–3.40) indicates a moderate level, [3.40–4.20) indicates a high level, and [4.20–5.00] indicates a very high level.

The first research task was to investigate the participants' attitudes to the quality and effectiveness of online mathematics teaching in general and to their experiences during the COVID-19. The overall findings, presented in Table 5, show that students in general share negative attitudes toward online mathematics teaching (GA: M = 2.34; SD = .79). On the other hand, they evaluate their experience with

online mathematics teaching during the COVID-19 pandemic as moderate (OE: M = 2.70; SD = .71).

With the second research task we wanted to investigate whether participants' attitudes and experiences are determined by the educational-scientific field (ESF) to which the study program they attend belongs. Kolmogorov-Smirnov test of normality revealed that the GATOM and OMTE scores were not normally distributed across the groups. Therefore, in order to examine possible differences in attitudes in terms of the ESF, Kruskal-Wallis test was performed.

Table 6. Comparison of the GATOM scores in terms of the ESF

		M	SD	Mean Rank	χ^2	df	Sig.
GATOM	SS&H	2.61	.80	135.22	17.729	2	.000
	TTS	2.18	.76	100.27			
	NS&M	2.16	.71	95.90			

Results of Kruskal-Wallis test indicate that there is a statistically significant difference in attitudes ($\chi^2 = 17.729$, df = 2, p = .000) in general in regard to the ESF (Table 6). To identify the difference among the groups the Dunn test was performed to reveal in which groups a significant difference in the GATOM scores occurred. A significant difference was noticed between SS&H and NS&M, as well as between SS&H and TTS students. SS&H participants express more positive attitudes toward online mathematics teaching in comparison to NS&M (p = .000) and TTS (p = .003) ones.

When it comes to individual items, we found that there is a statistically significant difference for items A1 ($\chi^2 = 14.540$, p = .001), A2 ($\chi^2 = 16.649$, p = .000), A3 ($\chi^2 = 7.495$, p = .024) and A6 ($\chi^2 = 9.872$, p = .007). SS&H participants express a more positive attitude compared to TTS (A1: p = .002; A2: p = .002; A6: p = .050) and NS&M (A1: p = .003; A2: p = .002; A3: p = .045; A6: p = .012) ones.

Table 7. Comparison of the OMTE scores in terms of the ESF

		M	SD	Mean Rank	χ^2	df	Sig.
OMTE	SS&H	2.91	.67	133.36			
	TTS	2.55	.69	99.16	14.765	2	.001
	NS&M	2.59	.73	99.35			

The Kruskal-Wallis test was conducted to determine if OMTE scores were different for three groups in regard to the ESF (Table 7). The findings showed that there was a statistically significant difference in OMTE scores between different groups of participants ($\chi^2 = 14.765$, df = 2, p = .001). We performed the Dunn's post hoc test for pairwise differences. A significant difference was noticed between the SS&H and NS&M, and between SS&H and TTS participants. SS&H participants report more positive experience with online mathematics teaching than NS&M (p = .003) and TTS (p = .003) ones.

When it comes to individual items, we found that there is a statistically significant difference for items E1 ($\chi^2 = 14.310$, p = .001), E2 ($\chi^2 = 8.538$, p = .014), E6 ($\chi^2 = 7.951$, p = .019) and E11 ($\chi^2 = 20.911$, p = .000). SS&H participants express a more positive attitude compared to TTS (E1: p = .001; E11: p = .000) and NS&M (E2: p = .017; E6: p = .015; E11: p = .000) ones.

Bearing in mind the given statement that the focus of the study programs of the faculties belonging to the field of SS&H sciences is on the acquisition of elementary and basic mathematical knowledge, in relation to the study programs at the faculties in the field of TTS and NS&M sciences, where students are expected to be able to functionally apply the acquired mathematical knowledge in practice, the research results confirming that participants in the field of SS&H sciences express more positive attitudes towards online mathematics teaching compared to the participants in the NS&M and TTS fields are not surprising. Assuming that their expectations from teaching and teachers are also lower, participants in the SS&H field express more positive experiences with online teaching compared to the ones in the TTS and NS&M fields, they are satisfied with their participation and motivation to work in online mathematics teaching, and give it a preference in comparison to live classes.

The complexity of teaching content and the willingness of participants to apply them in practice imply a more complex design of teaching content and activities for participants in the TTS and NS&M field, the need for permanent practice, checking and analysis of achievements, which also determines their more positive attitudes in relation to the organization of live classes. Also, we cannot overlook the importance of using cognitive metaphors, which facilitate abstract thinking by helping students to conceptualize and comprehend complex mathematical topics (Cassibba et al., 2021). Mathematics teachers, while using mathematical language, also utilize their bodies and gestures to help students grasp abstract concepts through metaphorical mappings to experiences of the human body. Nonverbal aspects of communication, such as gestural movements, facial expressions, and eye contact, provide teachers with insights into whether students have understood the content and if adjustments are needed (Breda, Farsani, Miarka, 2020; Chirinda, Ndlovu, Spangenberg, 2022; Zeki, 2009). All of these is significantly reduced in online settings. We can assume that these are the reasons why participants in the field of TTS and NS&M sciences, compared to the ones in the field of SS&H sciences, express a lower degree of agreement with the statements A1, A2, A3, and A6, stating that online teaching of

mathematics is as effective as traditional classroom teaching, that online teaching mathematics students acquire better and more permanent mathematical knowledge, that it provides more opportunities for students to develop critical and logical thinking, and that communication between students and the teacher during online mathematics classes is better than during live classes.

We believe that the fact that participants of the SS&H field express more positive attitudes and report a more positive experience with online mathematics teaching can be explained by the fact that the mathematical content provided by the study programs of the SS&H faculty is less complex than the one studied in other study programs. Its explanation and interpretation are not too demanding, unlike the mathematical content taught to participants in the TTS and NS&M fields. The content of the fields such as linear algebra, mathematical analysis, calculus, analytical geometry, differential equations, etc. require the use of specific mathematical symbols and notations and complex mathematical language which might be reduced due to the constraints of communication while teaching online mathematics and using digital tools (Noviani, 2021).

It is interesting to note that only SS&H participants study geometric content as part of their tertiary mathematics curricula. Geometric content presents a challenge to students and pupils even in normal circumstances, as indicated by the studies (Oflaz et al., 2016; Purnomo & Machromah, 2018) and international student tests such as PISA and TIMSS (Đerić, Gutvajn et al., 2020; Milinković & Lazić, 2018). Nevertheless, the fact that SS&H field participants express a more positive attitude towards online mathematics classes than other participants can be attributed to two things: first, geometric content, regardless of the fact that it is provided for in the mathematics curriculum, occupies only a small part of it, and, second, it is about the content of Euclidean geometry that is studied at the level of elementary and high school mathematics.

The third research task was to investigate whether participants' attitudes and experiences are determined by the self-assessed mathematics knowledge level. Since Shapiro-Wilk test of normality indicated that GATOM and OMTE scores were not normally distributed in all groups, the Kruskal-Wallis test was conducted.

Table 8. Comparison of the GATOM and OMTE scores in terms of the MKL

		M	SD	Mean Rank	χ^2	df	Sig.
GATOM	Low	2.36	.71	116.03	5.089	2	.079
	Medium	2.42	.77	119.85			
	High	2.20	.85	98.04			
OMTE	Low	2.55	.66	97.89	3.701	2	.157
	Medium	2.76	.69	119.74			
	High	2.68	.76	107.95			

The results of Kruskal-Wallis test presented in Table 8 indicate that there is no statistically significant difference in attitudes and experiences with regard to the self-assessed level of mathematical knowledge (MKL). Participants who report average level of MKL express the most positive attitudes toward online mathematics teaching and also report the highest level of satisfaction with their own experience with online mathematics instruction. On the other hand, participants who report advanced level of MKL express less positive attitudes toward online mathematics teaching in comparison to the other two groups. They are more satisfied with their online mathematics teaching experience. In contrast, participants with weak level of knowledge have more positive attitudes toward online mathematics teaching, but are less satisfied with their own online mathematics teaching and learning experience.

When it comes to individual items, we found that there is a statistically significant difference for item A5 ($\chi^2 = 8.050$, $p = .018$). Participants who rate their knowledge as advanced express a higher degree of agreement with the statement that mathematics is not a subject that can be taught online compared to participants who rate their knowledge as average ($p = .014$).

Also, we found that there is a statistically significant difference for items E5 ($\chi^2 = 8.669$, $p = .013$), and E10 ($\chi^2 = 13.016$, $p = .001$). Participants who evaluate their mathematical knowledge as advanced consider that they have more developed ICT skills necessary for participating in online classes compared to participants who evaluate their mathematical knowledge as weak ($p = .010$). Similarly, this same group of participants expresses a higher degree of agreement with the statement that they would be more active in mathematics classes to do mathematical tasks if the teaching was carried out live compared to participants who evaluate their mathematical knowledge as average ($p = .003$) and weak ($p = .013$).

We are not surprised by the result we reached in this research, that participants who consider themselves to have an average level of MKL express the most positive attitudes towards online mathematics classes and state the highest level of satisfaction with the experience gained in such organized teaching activities, while participants who consider themselves to have advanced level of MKL, although they are satisfied with the acquired experiences, have less positive attitudes towards online mathematics teaching. It is clear that participants with advanced level of MKL have a higher level of aspiration and higher expectations from teachers in relation to the organization of teaching activities, the teacher's role in them and planned learning outcomes. In live classes, students expect a joint analytical approach to teaching content (students and teachers), encouraging students to combinatorial flexibility in solving tasks, permanent monitoring and guidance of students, by the teacher, in teaching activities. These are probably the reasons why these participants believe that mathematics is not a subject that can be taught online, although they emphasize that they have the skills necessary to participate in such an organized class. The question arises as to how much online teaching provides the opportunity for this kind of work organization and how

much both teachers and students, at the time of the outbreak of the pandemic, could have been trained for such work in online teaching.

Also, it could be assumed that participants who consider themselves to have a weak level of MKL, although they have positive attitudes about online teaching, will be less satisfied with the experience gained in this way. It is clear that their involvement in online teaching was probably more modest, thus the experience was insufficient. In situations where they do not have enough knowledge and when they do not manage in different learning situations, participants are often not motivated to participate in activities. In such circumstances, online teaching can be a "cloak" for them to hide their ignorance and indolence during teaching activities. This may be the reason why they express positive views about online classes, but at the same time they are dissatisfied with the experiences they have gained, which often include failure in exams.

Conclusion

The sudden pandemic outbreak put educational systems into situation they had never experienced before. In order to be ready for future challenges and demands of modern society, universities all over the world have to consider creating and developing effective student-centered online courses. This requires addressing issues such as university teachers' training in terms of using adequate teaching pedagogies and tools, changing the roles of students in the teaching process, increasing student engagement and success rate, avoiding plagiarism and cheating, etc. The aim of our research was to determine whether it was possible to achieve a high quality of student work and the effectiveness of teaching during the COVID-19 pandemic through the appropriate organization of online classes, at faculties where mathematics is not the dominant scientific field. The results indicate that the students' attitudes towards online mathematics classes are generally negative. However, differences have been observed that are related to the dominant educational-scientific fields of the study programs studied by the participants. Participants whose study programs mainly belong to the SS&H field expressed more positive attitudes about online teaching than those whose study programs belong to the TTS and NS&M field, even giving an advantage in comparison to regular classes. Taking into account the self-assessed mathematical knowledge of MKL, students with average level of MKL express the most positive attitudes towards online teaching, while on the other hand, participants with advanced level of MKL, although they are satisfied with the acquired experience, believe that mathematics is not a subject that can be successfully taught through online teaching. As expected, participants who consider that they have a weak level of MKL are not satisfied with the experience gained in this way, despite the expressed positive attitudes about online teaching. Nevertheless, we are aware that the scope of this study is somewhat limited due to the fact that it encompassed only three state universities and one private university. Also, the study focused on the perceptions based on one point of

the view only – that of the students'. As online teaching may be an increasingly frequent need and necessity, it would certainly be useful to conduct research in the same direction on a much larger sample and include the other party – university teachers. Finally, can the online environment completely replace traditional teaching? The answer is certainly – no, but it is precisely this that obliges us to further research in this direction, considering the increasingly frequent challenges that are imposed on our society and the new roles of teachers.We can assume that the results of this research could be beneficial for university teachers in improving pedagogical practices, primarily through effective planning and organization of blended teaching, to address the previously mentioned issues that students face in mathematics classes, such as assessment, task overload, interaction with other students and teachers, and taking responsibility for their own learning. We believe that in mathematics classes, as well as in other subjects, combining online and face-to-face teaching would contribute to a more effective development of students' independence, initiative, and collaboration in solving mathematical problems, while keeping in mind that the direct presence and guidance of a teacher remain an irreplaceable method in working with students. Additionally, such an approach would foster the development of students' competencies for lifelong learning, such as communication, scientific, digital, and other competencies. At the same time, the blended teaching model presents a challenge for both teachers and students in the process of assessing and evaluating learning outcomes in the context of these competencies. In pedagogical theory and research, the results of this study could serve as a good starting point for considering new research questions related to learning outcomes through the application of various teaching approaches that include the possibility of blended learning models (e.g., programmed, problem-based learning, etc.). Furthermore, these competencies for lifelong learning could be a significant research question in the context of achieving educational goals in blended mathematics teaching at university level. For example, how digital competencies influence the development of students' independence and self-confidence in a blended learning environment.

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СТАВОВИ СТУДЕНАТА О ОНЛАЈН НАСТАВИ МАТЕМАТИКЕ ТОКОМ ПАНДЕМИЈЕ

РЕЗИМЕ

Пандемија ковид-19 приморала је универзитете широм света да пређу са наставе уживо на наставу у онлајн окружењу. Настава математике у онлајн окружењу донела је многе изазове за наставнике због своје изразито симболичке и дијаграмске природе. Циљ истраживања био је да се утврди да ли је могуће постићи добар квалитет рада студената и ефикасност наставе организовањем онлајн часова математике на нематематичким факултетима у Србији. Фокус истраживања био је на ставовима студената о онлајн настави математике, у односу на образовно-научне области студијског програма који похађају и самопроцене нивоа сопствених математичких знања. Спроведено је са студентима основних студија (N = 224) седам факултета/департмана три државна и једног приватног универзитета током 2022. године. За анализу података коришћене су и квантитативне и квалитативне методе. Резултати истраживања упућују на закључак да студенти основних студија из нашег узорка углавном нису исказали позитивне ставове према онлајн часовима математике. Такође, њихови ставови одређени су образовно-научном облашћу студијских програма које похађају, као и нивоом самопроцењених математичких знања. Сматрамо да добијени резултати могу бити значајна полазна основа за нова истраживања о квалитету и ефективности наставе, којима би се обухватили универзитетски наставници који су организовали онлајн часове математике.

Кључне речи: *онлајн настава математике, ставови студената, образовно-научно поље, ковид-19.*