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Original scientific paper
UDC: 371.21
DOI: 10.5937/IstrPed2401028M

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EMBRACING TECHNOLOGY IN DISTANCE MATHEMATICS EDUCATION: INVESTIGATING STUDENTS' PERCEPTIONS OF THE TEACHERS' USAGE OF THE PEN TABLET

Abstract: The inability to directly communicate mathematical content through various representations of concepts presented a significant challenge after the shift from face-to-face teaching to distance mathematics education in Serbia. Some mathematics teachers attempted to overcome this gap by using a pen tablet during mathematics classes. The aim of this research is to determine the attitudes of upper-grade elementary and high school students about whether the meaningful use of a pen tablet by teachers contributes to the quality of distance mathematics education. The examined sample included 202 students from upper elementary and high school. The research results indicate that students are indeed aware of the benefits of teachers using a pen tablet to achieve learning outcomes. In most specific statements, there are no significant differences in the attitudes of elementary and high school students, as well as differences in attitudes in relation to gender. Specifically, girls, to a greater extent than boys, agree with the statement that the use of a pen tablet helped them better understand the teaching and learning contents, as well as that there are more benefits to using a pen tablet in classes that cover arithmetic (algebra) topics. On the other hand, high school students, to a greater extent than elementary school students, perceive the use of a pen tablet in math classes as more effective and consider it more helpful during learning in mathematics classes.

Keywords: distance learning, elementary and high school students' attitudes, mathematics education, pen tablet.

Introduction

Even though distance learning had been studied before, after the pandemic caused by the virus COVID 19, it has become highly relevant and the subject of numerous recent research studies (Arsenijević, Belousova, Tushnova, Grosseck, & Mesaroš Živkov, 2022; Golubović-Ilić, Ćirković-Miladinović, & Vukićević, 2023), to various scientific fields and school subjects. Consequently, many researchers, both on a global scale and within the territory of the Republic of Serbia, have conducted research on the topic of mathematics education (Kunwar, Pokhrel, Khanal, & Sapkota, 2023; Lazić, Maričić, Marić, & Mrđa, 2022; Milenković, Aleksić, & Saković, 2022; Vulović, Mihajlović, & Milikić, 2022). These research ranges from the effects of distance learning to exploring its advantages and disadvantages and investigating the limitations of distance mathematics education from the perspectives of various educational stakeholders (teachers, students, and parents). The effects of using a wide range of learning platforms, digital tools for creating and sharing teaching

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materials, and knowledge assessment applications for students have also been analyzed (Alabdulaziz, 2021; Mihajlović, Vulović, & Maričić, 2021).

One of the tools whose usage has increased in the Republic of Serbia, especially in the field of distance mathematics education, is the pen tablet. The reason for the enthusiastic adoption of pen tablets by mathematics teachers with at least minimal digital competencies is quite evident. Mathematics teachers traditionally use a chalkboard or whiteboard during lessons to present concepts and procedures specified in their teaching process. By using appropriate notations, sketches, and constructions, teachers can represent mathematical concepts in various ways, depending on the characteristics of these concepts. Often, to make students more active and help them better understand and connect instructional content, teachers use various representations of mathematical concepts (Attard & Holmes, 2020). As the transition from face-to-face teaching to distance learning represents a significant change in the planning and implementation of mathematics education, the pen tablet has emerged as a tool that facilitates this transition, both for mathematics teachers and students (Karal, Kokoc, Colak, & Yalcin, 2013).

With this research, we aimed to examine the opinions of students whose mathematics teachers used a pen tablet during their lessons. We wanted to determine whether students considered the use of a pen tablet by teachers to be beneficial, whether it had a positive impact on the quality of mathematics education, the quality of lessons concerning various types of teaching content, and different types of mathematics classes.

Theoretical framework

Integration of technology in remote education and distance mathematics education

Sangra, Vlachopoulos, & Cabrera (2012) define distance learning as "an approach to teaching and learning that is based on the use of electronic media and devices as tools for improving access to training, communication, and interaction and that facilitates the adoption of new ways of understanding and developing learning" (p. 152). Andreev & Soldatkin (2022) similarly describe it as a purposeful process of interaction between teacher and students that is interactive between them and with learning tools, indifferent to participants' location in space and time and implemented in a specific didactic system. Poddubnaya et al. (2021) refers to distance learning as "a method based on the use of multimedia and internet technologies to increase the availability and quality of education" (p. 5), and the COVID-19 pandemic significantly affected the greater use of technology in distance teaching and learning. For instance, in the research of Alabdulaziz (2021), 97% of respondents reported a significant increase in the adoption of online education in schools after the outbreak of the COVID-19 pandemic. This shift has led to the widespread use of diverse software tools to enhance communication between educators and students (ibid, 2021). These tools include mobile technologies, touchscreens, pen tablets, digital libraries, the creation of learning materials in mathematics education, Massive Open Online Courses for mathematics, and Computer Algebra Systems (CAS) like Mathematica, MathCAD, Maple, and others. According to the results of numerous studies (Fabian, Topping, & Barron, 2018; Perienen, 2020), students achieve enhanced mathematics learning outcomes when they engage with effective and well-suited technology.

Despite the numerous advantages of distance learning, there are several challenges, particularly when teaching courses such as mathematics, including a lack of motivation, limited face-to-face contact between students and teacher, a lack of peer interactions, and potentially reduced interaction within the learning environment. These significant limitations of distance education and these constraints emphasize the crucial role of "interaction" in online learning (Klisowska, Sen, & Grabowska, 2020). Consequently, it is believed that achieving a high level of interaction between learners (students) and instructors (teachers) in an online learning environment is essential for enhancing the quality of online courses, such as mathematics courses (Karal, Kokoc, Colak, & Yalcin,

2015). Technological resources like PowerPoint, forums, blogs, online discussion groups, media, live chat, and written chat tools alone may not be adequate for fostering interaction and facilitating an effective learning experience in online mathematics instruction (Maclaren, 2014). Consequently, various emerging technologies, including pen-based technology, have been introduced to enhance interaction and feedback, especially in an online distance course (Mehlhorn et al., 2011). Radford (2008) explains that mathematical thinking happens through a sophisticated coordination of speech, symbols, gestures, and tools. Writing is necessary while doing mathematics (Artemeva & Fox, 2011). Limitation in the process of learning mathematics by online learners is explained by a lack of interaction in an online learning environment when mathematical concepts and symbols should be displayed (which play a significant role in mathematics education) using a keyboard and mouse (Bernhardt, Kress, Lewental, & Miller, 2004). Research conducted by Karal et al. (2013) demonstrates that mathematics teachers may encounter challenges when attempting to visually explain mathematical concepts in the context of online distance mathematics instruction.

When it comes to the usage of pen tablets in mathematics education, a study (Huang, Su, Yang, & Liou, 2017) has demonstrated that pen-based technology enhances student learning since such technologies enable students to improve their learning achievement and motivation in mathematics. Alabdulaziz (2021) concludes that the slides and images designed for the online distance mathematics course were created and employed as static visual resources with restricted interactivity, while on the other hand, pen-based technologies ease classroom interaction and communication in face-to-face learning environments, and that in an online environment during mathematics problem solving, instead of seeing operations step by step, students could see them all at once when the teacher used pen tablets. Using a digital pen or tablet in online education can contribute to better communication and interaction between students and the teacher, as well as increased student participation (Karal et al., 2015). In this context, Reins's (2007) study emphasizes that problem-solving in mathematics involves operational steps, and employing a pen tablet in these processes proves effective in enhancing students' visualization skills. In the same study it was found that the use of a digital pen in online mathematics courses reduced time loss, minimized distractions, and fostered active participation, consequently boosting students' interest in the course. Likewise, another study concluded that the integration of relevant technologies promoted active participation and enhanced student motivation (Casas, Ochoa, & Puente, 2009). On the other hand, in another study, researchers (Chen, Chiu, Lin, & Chou, 2017) claim that in activities involving touchscreens, students were able to sustain higher levels of attention, resulting in increased time-on-task and fewer distractions compared to those using pen tablets.

Another study has delved into the impact of using pen tablets in online mathematics education. The authors of this research (Karal et al., 2015) conclude that distance teaching and learning of mathematics without utilizing digital ink technology (as pen tablet) may result in limitations in terms of interactivity and pedagogy. Specifically, leveraging technologies like pen tablets to explain course content facilitates course design and management. In an online mathematics course, it is essential to employ digital ink technology and related technologies to illustrate concepts, symbols, and the steps of problem-solving, provide appropriate feedback, gain a high level of interaction, and deliver the course more effectively. Karal et al. (2015) emphasize that pen tablet technology has enabled instructors to feel more comfortable in the online learning environment and suggest that students in an online environment should also utilize digital ink technology in their mathematics course, just like online instructors. This proposal may enable the maximization of teacher-student interaction.

Multiple representations

The role of representation is to facilitate the shift from concrete to abstract thinking (Cassibba et al., 2021). In the learning process, representations of concepts are used to help students understand those concepts and connect them with other concepts. Multiple representations offer various

perspectives on the observed object, enabling the observer to analyze its attributes from diverse angles (Abu Bakar, Mohd Ayub, & Tarmizi, 2010). In the realm of mathematics, they provide a conducive setting for the abstraction and comprehension of fundamental concepts (Hwang & Hu, 2013). The categorization of representations has been the focus of extensive research. Two major groups of representations are considered: internal representations, which are formed within a students' mind, and external representations, which are created within students' environment (Nakahara, 2008). There are various classifications of representations based on their nature (Dwi, Subanji, Hidayanto, & Anwar, 2017). For example, Tall (2003) provides his own categorization called the "rule of four": Verbal; Graphic; Numeric and Symbolic (or analytic) representations.

The quality of multiple representations is greatly enhanced through the utilization of modern technology. Contemporary researchers are highly interested in employing technology to engage with multiple representations and establish connections among them (Rau, Michaelis, & Fay, 2015). For instance, if the mathematics teacher wants to bring algebraic representations together with graphical representations or with numeric representations, teacher can do it in class using chalk and a blackboard and introduce students to verbal representations of the chosen concept. But, on the other hand, when we discuss using multiple representations in the form of distance learning, this might be difficult. One way to bridge the gap is to use a pen tablet in mathematics class.

In Figures 1a, 1b and 1c pictures created during distance mathematics education while introducing mathematical concepts to students and solving tasks from different mathematical fields at different students' ages during their formal mathematical education are exhibited.

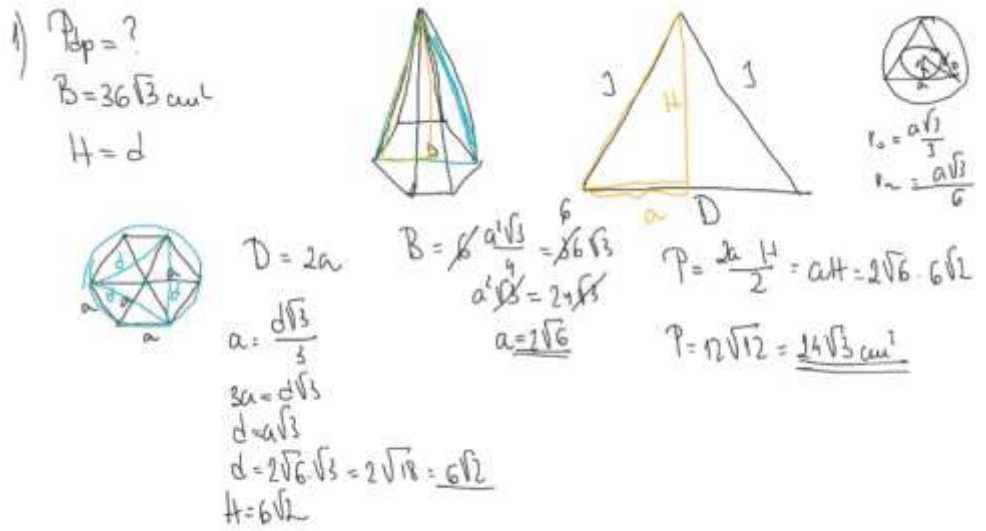

Figure 1a. *Solution for the concrete task from geometry with the usage of a pen tablet*

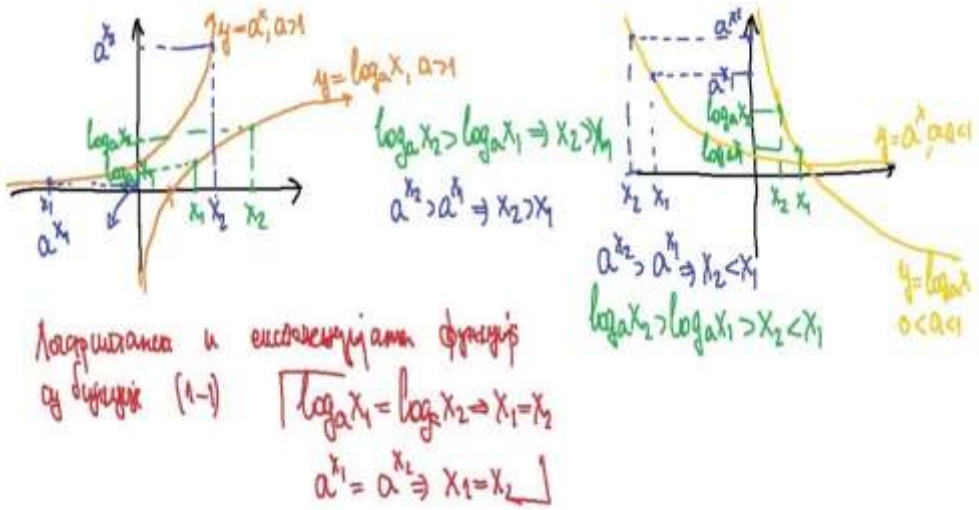

Figure 1b. *Exponential and logarithmic equations and inequalities with the use of pen tablet.*

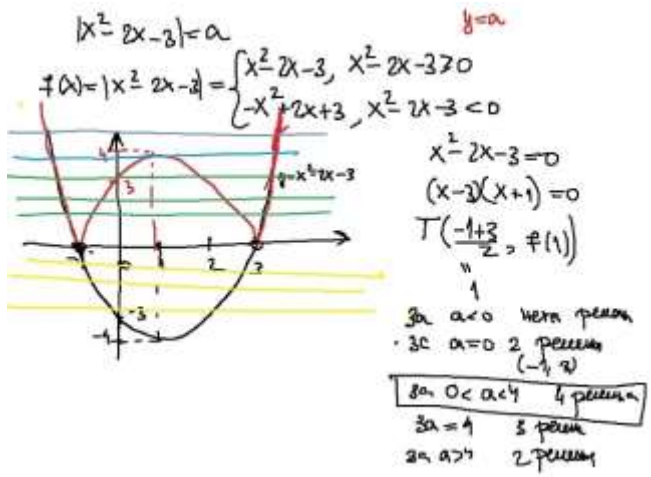

Figure 1c. *Solution for the task from quadratic function with the use of a pen tablet.*

Students' attitudes towards integration technology in the distance mathematics education

Arsenijević et al.'s (2022) findings indicate that students prioritize face-to-face mathematics education over online mathematics education. Less than 4% of students are willing to pursue their education through distance learning, and students view distance learning as a necessity related to preventing the spread of COVID-19 rather than as their preferred mode of education. The reasons for these attitudes of students can be found in the significantly reduced interaction between teachers and students in distance mathematics education and in the limitations that affect the teacher's ability to effectively convey content to students. Arsenijević et al. (2022) also claims that students in higher education are more likely to have a positive attitude towards distance learning than elementary and high school students and that the elementary and high school students are more concerned about the visibility of the graphic material for the mathematics class. In a different study (Peytcheva-Forsyth, Yovkova, & Aleksieva, 2018), the conclusion was that having a positive

attitude towards the use of ICT in education positively affects students' attitudes towards distance learning.

When it comes to the use of an interactive whiteboard in distance mathematics education, elementary and secondary school students in Turkey (Erdener, 2021) had a highly positive opinion about its application in mathematics education. In the same study, the results indicate that high school students are generally more satisfied with the use of the interactive whiteboard in an online learning environment, while there are no differences in the attitudes of boys and girls regarding the effectiveness of this practice, motivation, or negative aspects of using this technology in distance mathematics education. The results of another research (Erdener & Kandemir, 2019) speak in favor that students' attitudes towards the interactive whiteboard are positively influenced by their perceptions of its ease of use, compatibility, testability, and observability as characteristics.

Research methodology

The aim of this research is to determine the attitudes of upper elementary and high school students towards online mathematics education facilitated by teachers using a pen tablet to bring instructional content closer to students by employing multiple representations of concepts, with the intention of minimizing the gap resulting from the transition from face-to-face classroom teaching to online distance education. Two tasks of the research were identified in accordance with the aim of the research:

1. To assess students' attitudes towards online mathematics education conducted with the use of a pen tablet by teachers. This includes students' general impressions of such mathematics education as well as their evaluation of the technical quality of mathematical instructions provided by the teacher, taking into consideration the nature of mathematical content and the type of mathematics classes.
2. To investigate whether students' attitudes towards online mathematics education facilitated by teachers using a pen tablet are influenced by their age and/or gender.

The first part of the questionnaire used in the research included a brief description of the research's objective and information that the data collected through it would be used exclusively for scientific research purposes. Additionally, the first part of the questionnaire contained questions related to general information about the surveyed students (place, class grade, math grade, and student gender). The second part of the questionnaire consisted of thirteen statements concerning the quality and effects of online mathematics education facilitated by mathematics teachers using a pen tablet (the statements are presented in Table 1). It also included three open-ended questions addressing observed shortcomings and suggestions for changes, as well as suggestions from students about which classes for other school subjects the teacher could effectively use the pen tablet. Students expressed their degree of agreement or their views on various aspects of the mathematics education their teacher conducted by using a five-point Likert scale (1 strongly disagree, 2 somewhat disagree, 3 undecideds, 4 somewhat agree, and 5 strongly agree). Data collection was conducted by first reaching out to teachers from various cities across the Republic of Serbia to establish contacts with those who had used pen tablets in their work. Then we created a survey using Google Forms and distributed it to those teachers, who subsequently forwarded it to their students. All questions in the survey were mandatory.

The student survey was conducted at the end of the 2021/2022 school year, specifically in June and July 2022, with a convenient sample of 202 students from upper elementary and high school whose teachers use multiple representations of concepts in mathematics teaching process. Among the surveyed upper elementary students (a total of 117, or 57.92%), 15 students (7.43%) were from the 5th grade, 19 students (9.41%) from the 6th grade, 39 students (19.30%) from the 7th grade, and 44 students (21.78%) from the 8th grade. Among the surveyed high school students (a total of 85 students, or 42.08%), the sample included 15 students (7.42%) from the 1st grade, 12 students (5.94%)

from the 2nd grade, 31 students (15.35%) from the 3rd grade, and 27 students (13.37%) from the 4th grade. In terms of students' math grades, 44 students (21.78%) had a grade 5 in mathematics, 93 students (46.04%) had a grade 4, 32 students (15.84%) had a grade 3, and 32 students (15.84%) had a grade 2, while only one student had a grade 1 (0.5%). Regarding the gender distribution of the participants, the sample consisted of 120 female and 82 male students. The surveyed students attended elementary or high school in one of the following cities and municipalities: Belgrade, Kragujevac, Kruševac, Vršac, Kikinda, Prokuplje, Alibunar, and Bački Jarak.

The data obtained through student surveys was processed using the statistical software package SPSS 20. Descriptive statistical measures about the sample were provided, and the Chi-square test of independence was used as a statistical test.

Results and Discussions

The distribution of student responses, i.e., the degree of agreement with the given statements, is provided in Table 1. We can observe that the largest number of students strongly agreed with the statement that the teacher who used a pen tablet in the teaching process aimed to bring teaching and learning content as close to the students as possible (as many as 166 out of 202 student responses). On the other hand, the largest number of students strongly disagreed with the statement that they had difficulty following online lessons facilitated by a pen tablet (59 out of 202 student responses).

Table 1. *The level of students' agreement with the given statements*

No. of statement	Statement	I strongly disagree	I somewhat disagree	I am undecided	I somewhat agree	I strongly agree	M	SD
1	I am having difficulty with following online mathematics classes.	59	50	32	45	16	2.55	1.33
2	The mathematics teacher made an effort during online classes to bring the material closer and clearer to students as much as possible.	1	4	6	25	166	4.74	0.66
3	The pen tablet that the teacher used alongside their explanations was very helpful in helping me understand the material.	5	6	17	53	121	4.38	0.94
4	The use of the pen tablet by the teacher during the presentation of arithmetic concepts (determining expressions values, solving equations and inequalities, etc.) helped me understand the math contents.	4	13	15	53	117	4.32	0.99
5	The use of the pen tablet by the teacher during the presentation of geometry concepts (where the teacher drew pictures/sketches alongside mathematical notation) helped me understand the math contents.	3	13	18	46	122	4.34	0.98

6	The use of the pen tablet by the teacher during the lessons where we were introduced to new concepts, statements, and procedures greatly aided in their adoption and understanding.	3	5	17	64	113	4.38	0.86
7	The use of the pen tablet by the teacher during the lessons where we were reviewing and systematizing the educational content greatly helped me in deepening my knowledge and skills.	3	5	24	59	111	4.34	0.89
8	The use of the pen tablet by the teacher during the lessons positively affected the clarity of the notes.	4	16	43	57	82	3.98	1.06
9	The use of the pen tablet by the teacher during the lessons positively impacted the accuracy of the notes.	4	24	46	63	65	3.80	1.08
10	The use of different colors while using the pen tablet by the teacher during the lessons positively affected the notes quality.	3	13	43	37	106	4.14	1.06
11	The implementation of a math class involving the use of a pen tablet by the teacher is much more effective than classes where the teacher does not write, but only comments on the teaching materials.	5	11	27	37	122	4.29	1.05
12	The pen tablet has helped me during online math classes.	6	8	13	48	127	4.40	0.98
13	The pen tablet has helped math teacher during online math classes.	1	2	17	47	135	4.55	0.73

To better understand the extent to which upper elementary and high school students truly agree with the statements supporting the positive impact of using a pen tablet in distance mathematics education, we calculated the mean scores of their responses (Table 1) for each of the 13 statements. To determine how students generally perceive specific aspects of using a pen tablet by their mathematics teacher, we calculated the range of the five-point Likert scale (Narli, 2010): For mean scores ranging from 1 to 1.8, we can conclude that, on average, students strongly disagree with the statement; for scores from 1.81 to 2.6, they somewhat disagree on average; from 2.61 to 3.4, they are undecided on average; from 3.41 to 4.2, they somewhat agree on average; for mean scores ranging from 4.21 to 5, we can conclude that, on average, students strongly agree with the given statement.

Upon examining Table 1, we can observe that, on average, students somewhat disagree with the statement that they find it difficult to follow distance mathematics education when their teacher uses a pen tablet. This result suggests that students were generally successful in following

mathematics lessons when the teacher was able to deliver appropriate mathematical representations of concepts during class. It is interesting to note that the average responses of students to three statements indicate that they are somewhat satisfied, and all three statements relate to the technical quality of the records (statements 8, 9, and 10), specifically regarding the clarity of the notes, the visibility of the notes, and the ability to display them in multiple colours. These results are not surprising, given that pen tablets available on the market in Serbia vary in quality (and price), so there is a possibility that students were satisfied with the quality of the notes when their teachers used pen tablets with better visual display capabilities, while lower ratings were given by students whose teachers used pen tablets of lower quality. Such student responses also raise questions about the extent to which teachers themselves have mastered the technical aspects of using a pen tablet and how much they utilized different features (such as writing in different colours, varying line thickness, etc.) based on the platform they used for distance mathematics education.

On average, students totally agree with all statements related to the quality of mathematics education when a pen tablet is used by the teacher. They totally agree that mathematics education is efficient in situations where the mathematics teacher uses a pen tablet for making notes and sketches, regardless of its efficiency in general, the type of mathematics class, or the nature of the mathematics content. When considered individually, students expressed the highest level of agreement with statements related to the teacher's effort to make mathematics content more accessible to students when using a pen tablet ($M = 4.74$), and the statement that the use of a pen tablet helped both the teacher deliver mathematics contents ($M = 4.55$), and students better understand and grasp mathematical content ($M = 4.40$) (Table 1).

Based on the statistical indicators from student responses, we can conclude that students whose teachers used a pen tablet for writing mathematical notation, sketching images and graphics, and tabular presentation of concepts in the implementation of distance mathematics education are generally satisfied with the quality of such distance mathematics education.

In response to a first open-ended question regarding the recognition of the potential for effective use of a pen tablet in classes for other school subjects (based on students' experiences of a mathematics teacher's use of a pen tablet), 114 students (56.43%) answered that a pen tablet can be effectively used in physics classes, 42 students mentioned chemistry classes, and a total of 28 students mentioned languages (English and Serbian). In total, 22 students did not provide an answer to this question. Other students listed various individual other general education or vocational subjects. Interestingly, five students stated that a pen tablet could be successfully implemented in the teaching process "where the teacher needs a board", further illustrating that students have recognized the potential of the pen tablet, particularly in the context of teachers using it to facilitate the transition from face-to-face classroom teaching to distance mathematics education.

When asked what changes they would make (if they were to make any changes to the design of distance education that involved a mathematics teacher using a pen tablet), almost 90% of the students (178 of them) stated that they would not change anything in the design of distance education that involves a mathematics teacher using a pen tablet. Individual responses to this question are related to the pace at which the teacher writes and the precision and clarity of the teacher's notes.

The third open-ended question pertained to the disadvantages of distance mathematics education in general and was answered by only twelve students. Their responses mostly related to technical aspects of the implementation of education (internet connection, lower computer configuration used by the teacher or student), while two students simply believed that mathematics education cannot be successfully conducted through distance learning. Therefore, as many as 190 students

(94% of them) did not mention any shortcomings in distance education using a pen tablet. Considering that the question was mandatory and that students largely explicitly stated that they believe there are no disadvantages in distance mathematics education, this response from the students can be considered an additional confirmation of their satisfaction with mathematics education conducted using a pen tablet by the teacher.

In addition to the statistical indicators obtained from all surveyed students, we were interested in whether there were differences in students' attitudes based on their age and/or gender.

Students' attitudes towards usage of pen tablet in relation to students' grade level

When it comes to differences in the distribution of responses between elementary and high school students, or differences in the degree of agreement among students with the given thirteen statements, statistical analyses revealed differences in the responses of elementary and high school students in two statements. The first of these two statements related to the students' belief that the implementation of distance math classes involving the use of a pen tablet by the teacher is significantly more effective than distance math classes in which the teacher does not write but only comments on teaching materials ($\chi^2 = 14.04, p = 0.007$). Based on the graph shown in Figure 2, we can observe that the number of high school students who strongly agree with the statement is significantly higher in comparison to the total number of high school students, unlike the differences in the opinions of elementary school students. Furthermore, if we analyze the mean levels of agreement among students with this statement, the mean level of agreement for elementary school students is 4.09 (on average, they somewhat agree with the statement), while the mean level of agreement for high school students is 4.56 (on average, they strongly agree with the statement).

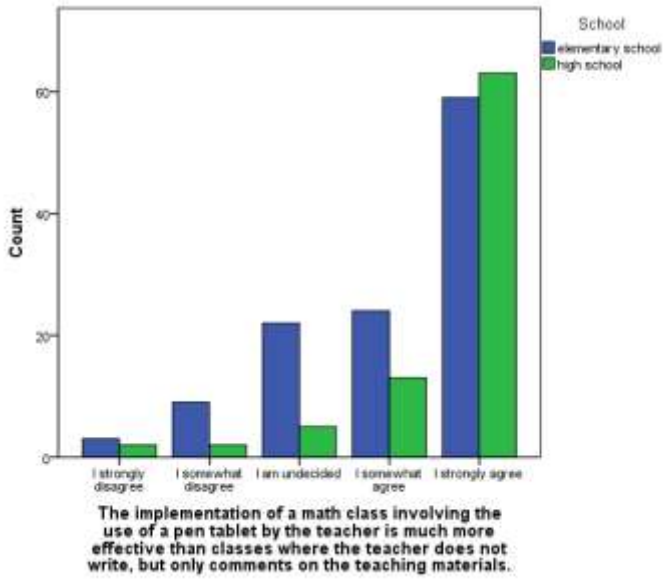

Figure 2. *Effectiveness of pen tablet usage by the math teacher in relation to students' age.*

The second statement on which elementary and high school students significantly differed in their responses relates to the students' belief that the pen tablet helped them during distance math classes ($\chi^2 = 9.70, p = 0.047$). Analyzing the graph shown in Figure 3, once again, we can conclude that high school students generally agree with this statement to a greater extent compared to elementary school students.

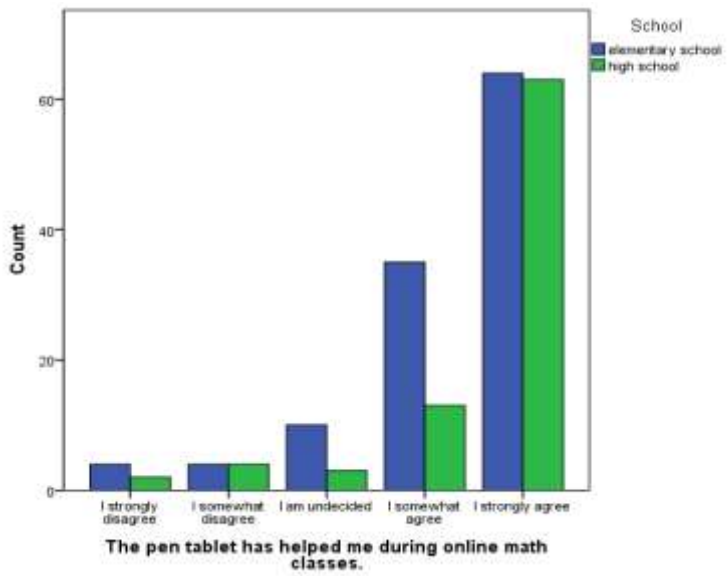

Figure 3. *To what extent was the pen tablet helpful for the students in relation to their age.*

Moreover, we can notice that the number of elementary school students and high school students who strongly agree with this statement is almost the same. However, there are almost twice as many elementary school students who somewhat agree with this statement compared to the number of high school students who somewhat agree or are undecided that the use of a pen tablet by the teacher significantly helped them acquire knowledge and skills in mathematics during distance learning. The arithmetic mean of the degree of agreement of high school students with this statement is 4.54, while the arithmetic mean of elementary school students is 4.29.

Since, by analyzing the students' responses regarding whether they attend elementary or high school, we obtained statistically significant differences in the students' responses in two statements, we were interested in whether these differences in agreement with this or other statements would manifest if we divided students from older elementary school grades and high school into more groups according to the school grade they attended. Therefore, we observed the responses of four groups of students: the first group consisted of fifth and sixth-grade students; the second group consisted of seventh and eighth-grade students; the third group were younger high school students (first and second-grade high school students); and the fourth group were older high school students (third and fourth-grade high school students).

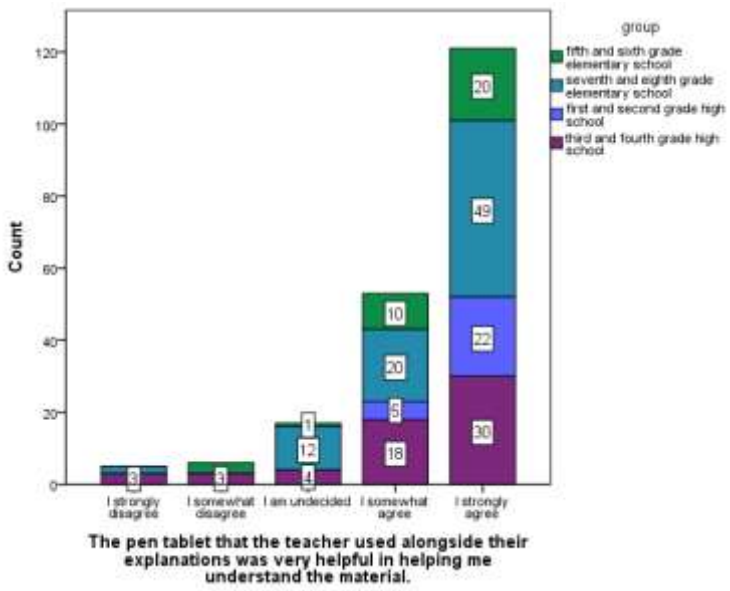

Figure 4. *Understanding of teaching materials in relation to students' age.*

The responses of students from these four groups significantly differ when it comes to the statement that mathematics distance education, where the math teacher uses a pen tablet, is much more helpful for students to understand the mathematics teaching material ($\chi^2 = 22.76, p = 0.03$). It can be noticed (Figure 4) that the ratio of the number of students who partially or completely agree with this statement to the total number of students in the group is the highest in the group of younger high school students (1st and 2nd grades of high school). These student responses can be seen in the context of the significantly increased level of abstraction in teaching materials compared to previous mathematical education and the importance of having appropriate representations of mathematical concepts available to students during math class. The considerably more pronounced positive attitude of 1st and 2nd grade students can also be related to the teaching content covered in the curricula for these grades, where multiple representations enabled by a pen tablet contribute to students' better understanding.

Students' attitudes towards usage of pen tablet in relation to students' gender

Also, we were interested in whether the extent to which students agree with specific statements differs based on the students' gender.

We once again compared the students' responses using the appropriate Chi-square test, this time between male and female students, and once again, we obtained statistically significant differences in students' responses for two statements. Thus, regarding the statement that the use of a pen tablet by the teacher significantly enriched distance mathematics education and contributed to a better understanding of the curriculum with the teacher's explanations that accompanied their notes on the pen tablet, there are statistically significant differences in the responses of male and female students ($\chi^2 = 12.24, p = 0.016$).

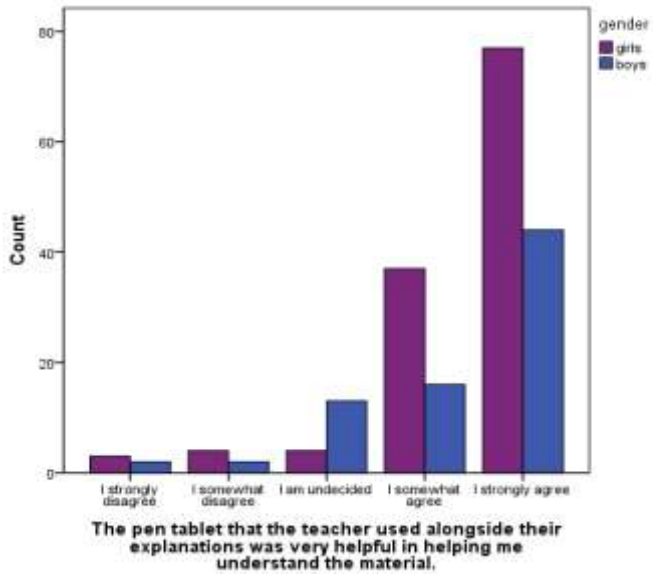

Figure 5. *Understanding of teaching materials in relation to students' gender.*

Based on the chart shown in Figure 5, we can see that the ratio of the number of female students who somewhat agree or completely agree with this statement to the total number of female students is significantly larger than the ratio of the number of male students who somewhat agree or completely agree with this statement to the total number of male students.

When it comes to the teaching and learning contents, which, of course, have specific characteristics, the attitudes of male and female students regarding the use of a pen tablet during lessons focusing on geometric content did not differ significantly. On the other hand, there is a statistically significant difference in the degree of agreement between male and female students with the statement that the use of a pen tablet by the teacher during the presentation of arithmetic concepts helped students understand the corresponding mathematical content ($\chi^2 = 11.59, p = 0.021$). Based on the chart shown in Figure 6, we can conclude that the use of a pen tablet by the teacher was of greater significance to female students compared to male students in lessons where students determined the value of expressions, solved equations and inequalities, worked with polynomials, and so on. Considering that algebraic representation of arithmetic content involves writing one expression after another, or simpler equations equivalent to another equation, and similar aspects, it turns out that the presence of clear and systematic notes of algebraic representations of concepts means much more to female students compared to male students. The research results of Saleh & Rahman (2016), which indicate better achievements of female students in algebra compared to male students, provide additional confirmation of this conclusion.

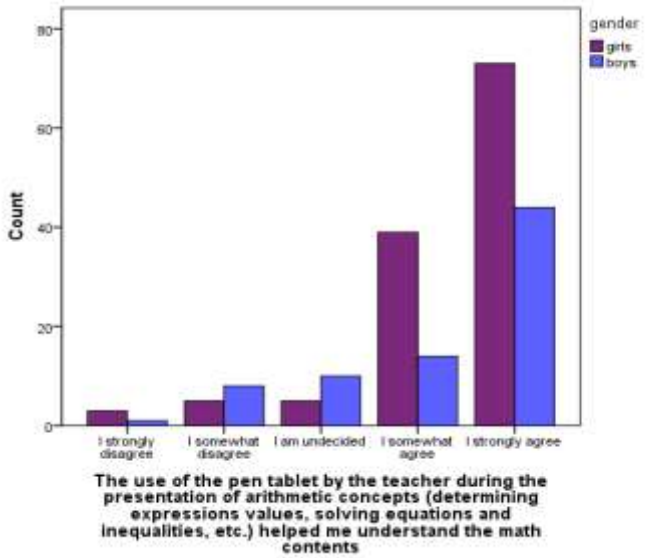

Figure 6. *Understanding of arithmetic concepts in relation to students' gender.*

Conclusion

Based on the research results, we can conclude that older elementary school students and high school students have a high opinion of distance mathematics education that is conducted using a pen tablet by the teacher. We found that students have a low level of agreement with the statement that they had difficulties in mathematics classes where the teacher noted mathematical concepts using various representations. Furthermore, as mentioned earlier, students are somewhat satisfied with the quality of the notes (precision, clarity, and colour choices during writing and drawing). This result can have various backgrounds, one of which is related to the quality of the pen tablets themselves, while the other is related to the insufficiently developed digital competencies of teachers to optimally use the pen tablet in relation to the objectives and planned learning outcomes. This conclusion is in line with the research results of Mihajlović et al. (2021), in which they state that teachers are accustomed to using digital tools as a support in classroom teaching. This, in turn, could be a direction for further research and professional development for teachers.

With all the other statements supporting the idea that distance mathematics teaching is of higher quality when the teacher uses a pen tablet (along with oral explanations) to positively impact student understanding, that mathematics teaching gains in quality regardless of whether it involves content from arithmetic (algebra, logic, and mathematical analysis) or geometry, whether it's lessons of introduction of mathematical concepts and procedures or practice lessons and systematization, and that the teacher has left an impression of putting much more effort into conveying the intended knowledge and skills to students, on average, students fully agree.

It is important to emphasize that as students become more mature and as the educational content becomes increasingly abstract, the meaningful use of a pen tablet by the teacher, along with the presence of external concept representations, becomes more valuable for students to acquire and create their internal representations of these concepts adequately. The significance of the availability of concept representations (especially algebraic representations), along with suitable explanations from the teacher, is more pronounced among female compared to their male peers. Another difference in the attitudes of students of different genders concerns the importance of

using a pen tablet in the implementation of arithmetic mathematical content because solving these tasks step by step with appropriate algebraic notation is something students, especially female students, are accustomed to in regular mathematics classes that take place in face-to-face school environments. This attitude of female students can be linked to their higher levels of achievement in working with algebra content, confirming the findings of earlier studies (Murugan & Rajoo, 2013; Saleh & Rahman, 2016).

Additionally, students were quite reserved when mentioning disadvantages and suggestions for corrections in distance mathematics teaching and learning. However, their recognition of school subjects in which a pen tablet can be successfully implemented into the teaching process supports the idea that these are indeed subjects where teachers more extensively use various forms of concept representations, from words to graphics and formulas.

Finally, the use of a pen tablet clearly offers significant advantages for students in the implementation of distance mathematics education. Future research should explore the attitudes of teachers regarding the importance of using a pen tablet and compare them with students' attitudes. Furthermore, to make distance mathematics education more productive in terms of interaction between teachers and students, as well as among peers, it will be interesting to consider the utilization of pen tablets by both teachers and students and examine the effects of such an approach to distance mathematics education.

Acknowledgements

The co-authors of this paper would like to express their gratitude to all their fellow teachers who assisted in collecting data, specifically in surveying the students.

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