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TEACHERS' PERCEPTIONS OF INSTRUCTIONAL GUIDANCE IN ONLINE MATHEMATICS TEACHING[1]

Abstract: The purpose of the research was to examine teachers' perceptions of the requirements and benefits of using indirect versus direct instruction in online mathematics teaching and its relation with socio-educational variables. Also, it is examined whether, compared to other subjects, teachers more often apply a certain type of instruction in mathematics classes, and what teaching materials and tools for communication they use when applying direct and indirect instruction in online mathematics teaching. The results showed that teachers perceive the benefits and requirements of indirect instruction compared to direct instruction, and this perception is a slightly determined by levels of their education and work experience. About half of teachers, use direct instruction more often in online mathematics classes, compared to the other subjects. They use a wide range of teaching materials and tools for communication. The results have implications for the further professional development of teachers in the domain of using direct and indirect instructions in mathematics teaching.

Keywords: direct and indirect instruction, online mathematics teaching, primary education, teachers' perceptions.

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INTRODUCTION

The influence of instructional guidance in the teaching process is still not fully clarified in the related literature. In the scientific community, there are no agreed upon positions regarding how much instructional guidance should be provided in the learning process i.e., when it is necessary to provide explicit/direct support, and when only to guide independent student activities (Lee, Anderson 2013). Moreover, the results of the research are often completely opposite. The problem of determining the appropriate and optimal instructional guidance in mathematics teaching is a very complex problem that needs to be viewed from different perspectives. With this work, we want to make a contribution to the current research that is being carried out in order to determine the necessary level of instructional guidance in mathematics classes, while taking into account all the complex factors that affect the learning process. Our current focus is on online mathematics instruction, due to the expectation that online instruction will continue to have a significant place in the educational system.

THEORETICAL BASIS OF RESEARCH

When talking about instructional guidance, direct and indirect instructions are most often mentioned i.e., direct and indirect instructional guidance. To avoid terminological confusion, we will first consider the concept of direct instruction. In the scientific literature, the teaching model referred to as *DI* ("capital *DI*") and the method of instructive guidance referred to as *di* ("little *di*") are denoted by the same term (Nifdi 2022; Stockard et al. 2018). *DI* is an educational program (instructional model) that was developed in the 1960s by Zig Engelmann and his colleagues based on the assumption that for effective learning it is necessary to provide precise instructions, use well-chosen, sequenced examples, and that the transition to new concepts is possible only when the previous key concepts are mastered (Stockard et al. 2018). The term direct instruction (*di*) was introduced in 1976 by Rosenshine to define teacher strategies that are significantly related to student achievement (Nifdi 2022). Today, direct instruction refers to educational programs that apply explicit (direct) instruction (Stockard et al. 2018: 480), and also instructional guidance with full explanations of concepts, procedures, and problem-solving strategies (Kirschner, Sweller, Clark 2006). In this paper, by direct instruction (further *di*), we mean a highly guided instructional approach organized around key concepts within a certain teaching content that the teacher presents step by step, providing students with all the necessary explanations, ready-made answers, independent practice with explicit feedback, and check-ups on what has been learned (Cvjetićanin, Maričić 2022). Direct instructional guidance implies the decisive role of the teacher in preparing and providing all the necessary information, presenting models, facts, rules and procedures in the most explicit way (Aung, Khine 2020). From the founding of indirect instruction, which took place in the mid-1960s when it was scientifically proven that unguided learning does not produce the desired results, to its modern understanding as an approach that focuses on students and as much as possible engages their independence, productivity, imagination, creativity, etc., indirect instruction is understood as a different approach for different researchers (Loibi, Rummel 2013; Kittell 1957). This difference is reflected precisely in the optimal dosage of the offered guidelines, i.e., the quantitative determination of the minimum amount of guidance and its appropriate implementation in the teaching process (Maričić et al. 2022a; Maričić et al. 2022b; Matlen, Klahr 2013). Indirect instruction (further *ii*) means a less guided instructional approach organized around key concepts within a certain teaching content, which are presented to students step by step in the form of tasks or problems that they should realize or solve independently. Students should find the necessary explanations, then systematize, explain, and present what they have learned (Cvjetićanin, Maričić 2022; Eysnik, De Jong 2012). During this process, students are offered guidance in the form of instructions that can be embedded in the presented tasks, in the form of references to additional sources of knowledge, in the form of implicit questions, or in the form of hints (Dignath, Veenman 2021).

We view instructional guidance as a continuum, at one end of which there is direct instructional guidance in which the teacher plays a dominant role, and at the other end there is minimal instructional guidance that enables students to independently and freely explore and construct knowledge. Between these two extremes there is room for finding a balance in the application of direct and indirect guidance of students in the process of acquiring knowledge. The debate about the advantages of one or another model of instructional guidance has been going on for more than 50 years. The arguments and evidence presented in these discussions indicate the complexity of the process of instructional guidance and the need to look at the problem from different points of view (Aung et al. 2020; Upu, Buhari 2014; Lee, Anderson 2013; Kirschner et al. 2006; Mayer 2004). In the category of minimally guided instruction, Kirschner includes problem-based learning and inquiry, and experiential and constructivist learning, without making an essential difference between these teaching approaches. According to Kirschner, minimally guided instruction cannot be effective primarily because it does not respect the human cognitive architecture and "learners should be explicitly shown what to do and how to do it" when dealing with novel information (Kirschner et al. 2006). Among the disadvantages of Kirchner's observation of teaching guidance, the following stand out: neglecting the role of motivation and the fact that it is very important that the studied contents make sense for the students themselves, identifying different teaching models with a minimally guided approach, and favoring instructional guidance that develops lower cognitive levels (Hmelo-Silver, Duncan, Chinn 2007; Kuhn 2007; Schmidt et al. 2007). The teaching models that Kirchner identifies with minimally guided instruction have proven their effectiveness with indirect instructional guidance and are based on the assumption that knowledge is built on the basis of personal experience (Kalyuga et al. 2001; Dean, Kuhn 2007; Alferi et al. 2011; Maričić et al. 2022a; Cvjetićanin et al. 2022; Brunstein, Betts, Anderson 2009). Therefore, students are not left alone in acquiring knowledge but receive support in the form of indirect instructions, peer interaction and assistance, and the use of technology (Upu et al. 2014; Hmelo-Silver et al. 2007).

The goal of learning mathematics is not only the mastery of mathematical concepts and the development of abstract, logical, and critical thinking, but also the development of "skills of knowledge acquisition – skills that equip a new generation to learn what they need to know to adapt flexibly to continually changing […]" (Kuhn 2007). Recent research points to the need for balanced instructional guidance in teaching mathematics (Aung et al. 2020; Upu et al. 2014; Oladayo, Oladayo 2012; DeCaro, Rittle-Johnson 2012; Jones, Southern 2003). Today, the prevailing understanding is that in teaching mathematics it is necessary to apply both direct and indirect instructional guidance, and that the greater challenge is to achieve a balance and the right sequence between them.

The COVID-19 pandemic instigated a series of innovative approaches to teaching and learning, including so-called online teaching, which is based on the use of modern educational technologies. The effectiveness of planning, preparation, and implementation of online mathematics lessons also depends on the teachers' perceptions of instructional guidance in online mathematics teaching. Online teaching means a form of distance education in an online environment and refers to situations in which the presence of the Internet supports the learning process (Fakhrunisa, Prabawanto 2020; Appana 2008). This learning does not depend on the physical or virtual location of the teacher and the student, and the teaching content is delivered online.

Regarding the aspect of instructive guidance, online mathematics teaching, as well as regular teaching, can be realized in two basic ways: with the application of direct and indirect instruction. It was confirmed that teachers have positive perceptions about the application of indirect instruction in learning mathematical content with the application of modern technology (Warner, Kaur 2017). The teachers stated that although the teaching of mathematical contents with direct instruction is easier, the results from the teaching with indirect instruction are much more pleasant. The teachers also encountered certain difficulties in their work, which are related to the technical side of working in the computer room, as well as to the fact that it is necessary to put the students in a position to think and thus adopt mathematical concepts, instead of just giving them a lot of examples, in order to prepare them for the test (Warner et al. 2017; Trybus 2013). Teachers' perceptions of student engagement in online teaching of geometric mathematics content (animated geometry) were examined (Aaron, Herlost 2015). It was found that teachers pay the most attention to sources that students can use correctly or incorrectly in their work, while they pay little attention to operations that students could apply in their work, as well as the goals that students should achieve while solving tasks. Inequality in the learning of mathematics content is also present in regular classes, but research has shown that it is significantly increased in online mathematics classes (Yılmaz et al. 2021). The results of this research are consistent with the results of numerous studies on this topic (Baysu, Ağırdağ 2019; Hohlfeld et al. 2017; Özdemir 2016). In addition, results confirmed that student engagement and interaction are not of the same quality during regular and online teaching (Yılmaz et al. 2021). The teachers declared that they encountered difficulties in applying various strategies and mechanisms for providing support and guidance to students, which affected their engagement and mathematical thinking. These data point to the fact that indirect guidance during online mathematics teaching has proven to be quite unsuccessful. Regarding the importance of using digital tools in promoting students' cognitive development, the teachers who are prepared for online teaching declared that they attach more importance to the research of mathematical concepts, to the technical demonstration, as well as to the discussion about what is shown on the screen, while the teachers who are not prepared for online teaching attach greater importance to the visualization of mathematical concepts and their mutual connection, to its explanation and to explaining mathematical representations (Guerrero-Ortiz, Huincahue 2020). The application that teachers used at the beginning of online classes was *WhatsApp*. Teachers mostly used videos, digital documents, and tutorials from the Internet. Teachers stated that they sent learning material to students in the form of modules, videos, and other materials, after which they directed students to online discussions or gave them online quizzes. Of the applications teachers most often used, *WhatsApp* and *Google Classroom* were used most for transferring materials; *Zoom*, *Google Meeting* and *Jitsi* were used for holding discussions; *Google Forms* and online quizzes helped to check what students; the most used application was *WhatsApp* (Guerrero-Ortiz et al. 2020; Fakhrunisa et al. 2020). For the disadvantages of online teaching, the teachers pointed out the following: teachers' readiness to launch applications and students' difficulty in using them, ignorance of the possibilities for more effective online tools that students can use, limitations in achieving learning that requires mathematical thinking, limitations in providing and receiving feedback, inability of some students to control the freedom with their time, and the need for direct guidance (for weaker students). For the advantages of online teaching, teachers pointed out: encouraging students to work independently, encouraging students and teachers to master the use of modern technologies, more flexible study time, adaptation of students to a more creative approach in performing tasks, and better storage of material that remains after the lesson. From the above facts, it is concluded that in the initial stages of online teaching of mathematics, it is necessary to offer professional training to teachers for working with certain digital tools, as well as direct instruction to students so that they can use all the benefits of this learning mode and acquire the necessary knowledge in this way. This would also improve communication between teachers and students. After a certain amount of time and the acquisition of adequate skills for working with digital tools, direct instruction could increasingly give way to indirect instruction, which would contribute to student independence in work and a more creative approach in performing their duties.

METHODOLOGY

THE PROBLEM, OBJECTIVES, AND METHODS

The subject of this research is the perception of the specific characteristics of the application of indirect versus direct instruction in online mathematics classes from the teachers' perspective. The research problem can be formulated in the form of the following question: how do teachers perceive the use of instructional guidance in online mathematics classes?

The main goal of the research is to examine the teachers' perception of the requirements and benefits of using indirect versus direct instruction in online teaching of mathematics. In addition, one of the objectives was to examine the impact of socio-educational variables, specifically teachers' work environment, level of education, and years of work experience on the way teachers perceive the application of indirect versus direct instruction in online mathematics classes. It was also determined whether, compared to other subjects, teachers more often apply a certain type of instruction in mathematics classes, as well as what teaching materials and tools for communication they use when applying direct and indirect instruction in online mathematics classes.

Theoretical analysis was used for explanation of the key concepts. The following methods were used in the research: descriptive-analytical method and methods of inferential statistics.

SAMPLE

The sample used in this research consists of 228 teachers in the first cycle of primary education in the Republic of Serbia. An overview of the characteristics of the sample can be found in Table 1. Currently, 2 respondents are pursuing professional studies, 9 respondents are pursuing academic studies, 10 are in master's programs and 11 are in doctoral programs.

Table 1. An overview of the characteristics of the sample

Gender		Environment		Level of education		Years of working experience	
Male	18	Urban	120	Professional studies	26	Less or equal to 10	43
Female	206	Rural	101	Academic studies	121	From 11 to 20	30
Non-binary	1	No answer	7	Specialist studies	3	From 21 to 30	101
No answer	3			Master studies	74	More or equal to 31	52
				Ph.D studies	1	No answer	2
				No answer	3		

INSTRUMENT AND PROCEDURE

For the purpose of our research, a questionnaire *Direct and indirect instruction in classroom mathematics* was created, which contains 13 questions as a part of our wider research. The first part of the questionnaire included socio-educational characteristics of the chosen sample, such as the environment in which the teachers work, their level of education, and their work experience. In the second part of the questionnaire, the respondents could express their agreement with the statements on a five-point Likert scale. For the purposes of data processing, respondents' answers were assigned values from 1 ("do not agree at all") to 5 ("totally agree"). In the closed-ended questions, the respondents could choose which type of instruction they use most often in online mathematics classes compared to other subjects. The questionnaire was created in an online format and distributed by sending a link through which respondents filled in the questionnaire electronically. The questionnaire was sent to all elementary schools in the Republic of Serbia, with the indication that is intended for teachers in first cycle of primary education. The data was processed in the statistical package IBM SPSS for Windows, version 20.

RESULTS

The first task of the research was to examine teachers' perceptions of the application of indirect instruction (*ii*), in relation to direct instruction (*di*), in online mathematics teaching. The first group of items refers to the requirements for the application of *ii* in relation to *di* in online mathematics teaching: The application of *ii* in relation to *di* in online mathematics teaching requires:

1. a more active role and greater engagement of the teacher (Item code R1),
2. greater methodological competence of the teacher (R2),
3. more time for teacher preparation (R3),
4. more material and technical resources (R4),
5. is more complex and can represent a professional challenge for teachers (R5),
6. a more active role and greater engagement of students (R6).

Descriptive indicators of the teacher's perception of the requirements for application of *ii* in relation to *di* in online mathematics teaching are presented in Table 2. From Table 2 we can see that the teachers least agree with the statement that the application of *ii* in relation to *di* in online mathematics teaching requires a more active role and greater engagement of students; the teachers most agree with the statements that the application of *ii* in relation to *di* in online mathematics teaching requires more material and technical resources and that the application of *ii* compared to *di* in online mathematics teaching requires more time for teacher preparation.

Table 2. Descriptive indicators of the teacher's perception of the requirements for application of *ii* in relation to *di* in online mathematics teaching

Items	*N*	1	2	3	4	5	*M*	*SD**
R1	222	3%	7.7%	20.7%	28.4%	40.1%	3.95	1.096
R2	222	1.4%	1.5%	18.9%	29.7%	40.5%	3.99	1.049
R3	224	2.2%	8.0%	16.5%	26.3%	47%	4.08	1.075
R4	224	1.8%	5.8%	16.5%	26.3%	47%	4.09	1.013
R5	219	1.4%	7.8%	18.3%	31.9%	40.6%	4.03	1.013
R6	225	6.2%	12.4%	19.6%	30.2%	31.6%	3.68	1.215

*Standard deviation

The second group of items refers to the benefits of indirect instruction compared to direct instruction in online mathematics teaching. The application of indirect instruction in relation to direct instruction in online mathematics teaching…

1. better equips students for independent work (Item code C1),
2. is more effective in terms of developing student competencies (C2),
3. contributes to the quality of interaction with students (C3),
4. encourages students' interest in teaching (C4).

Descriptive indicators of the teacher's perception of the contribution for application of indirect instruction in relation to direct instruction in online mathematics teaching are presented in Table 3. From Table 3 we conclude that the teachers least agree with the statement that the application of indirect instruction in relation to direct instruction in online mathematics teaching contributes to the quality of interaction with student; the teachers most agree with the statement that the application of indirect instruction in relation to direct instruction in online mathematics teaching better equips students for independent work.

Table 3. Descriptive indicators of the teacher's perception of contribution for application of *ii* in relation to *di* in online mathematics teaching

Items	N	1	2	3	4	5	M	SD
C1	225	6.2%	12.4%	19.6%	30.2%	31.6%	3.68	1.215
C2	223	6.3%	13.5%	20.2%	32.7%	27.3%	3.61	1.198
C3	222	5.9%	18.0%	23.4%	28%	24.7%	3.48	1.210
C4	225	7.2%	13.8%	24.0%	27.5%	27.5%	3.55	1.228

The Kolmogorov–Smirnov test (Sig. = .000) and Shapiro–Wilk test (Sig. = .000), as well as the shape of the histogram, showed that the scores on the all items were not normally distributed. Therefore, we used non-parametric methods for data analysis. The Mann–Whitney U test showed that there is no statistically significant difference on the items R1–R6 (p = .123–.779) and C1–C4 (p =.356–.919) in relation to the environment where the teacher works. The Jonckheere–Terpstra test for ordered alternatives revealed statistically significant differences on items R4 (T_{JT} = 8225000, z = 2.089, p = .037, r = 0.14 small effect) and C1 (T_{JT} = 8287500, z = 1.987, p = .047, r = 0.13 small effect) in relation to level of education. Groups of professional studies, academic studies, and specialist studies have a median of 4; groups master studies and Ph.D studies have a median of 5. The influence of the level of education on items R1–R3, R5, R6 (p = .128–.689) and C2–C4 (p = .119–.575) is not statistically significant. The Jonckheere–Terpstra test for ordered alternatives revealed statistically significant differences on item R6 (T_{JT} = 8447000, z = -1.982, p = .047, r = 0.13 small effect) in relation to years of working experience (Gp1 1–10 years, n = 42, Md = 4.28; Gp2 11–18 years, n = 26, Md = 4.26; Gp3 19–25 years, n = 32, Md = 4.09; Gp4 26–33 years, n = 82, Md = 4.02; Gr5 34+ years, n = 41, Md = 4.07).

In relation to other subjects in online mathematics teaching, 52.2% of teachers more often apply direct instruction, 14.7% of teachers more often apply indirect instruction, and 33% of teachers state that there is no difference compared to other subjects.

Furthermore, the teachers had to rate the extent to which they used the offered tools for communication with students and the implementation of online mathematics teaching using direct instruction on a scale from 1 ("did not use it") to 5 ("used it to a great extent"). The descriptive indicators are shown in Table 4. The most frequently used tool for communication with students in online mathematics teaching with direct and indirect instructions is Viber. Teachers reported that they have also used the RTS platform (sample lessons recorded on TV), *ClassDojo*, *MIT AppInventor*, *e-classroom*, *Messenger*, *Google Meet*, and *Discord* for both direct and indirect instruction.

Table 4. Descriptive indicators of the use of tools for communication with students and the implementation of online mathematics teaching when applying *di* and *ii*

Tool	Instr.	*N*	1	2	3	4	5	*M*	*SD*
Google Classroom	di	221	21.7%	9%	12.7%	15.8%	40.8%	3.45	1.599
	ii	217	27.2%	10.6%	10.6%	12.4%	39.2%	3.26	1.683
My Tesla classroom EDU	di	200	76.5%	7.5%	8.5%	3%	4.5%	1.52	1.070
	ii	200	77%	6%	6%	6.5%	4.5%	1.56	1.142
Microsoft Teams	di	197	3.4%	62.7%	12.3%	11.3%	7.4%	1.71	1.126
	ii	197	67%	11.2%	9.6%	7.1%	5.1%	1.72	1.199
Ed-modo	di	198	74.7%	10.1%	6.1%	3.5%	5.6%	1.55	1.120
	ii	200	77%	8.5%	6%	3.5%	5%	1.51	1.089
Jitsi	di	195	87.2%	5.6%	5.1%	2.1%	0%	1.22	0.632
	ii	197	85.8%	6.1%	5.1%	2.5%	0.5%	1.26	0.714
Online quizzes	di	211	30.3%	14.7%	22.7%	15.6%	16.6%	2.73	1.456
	ii	211	33.6%	16.1%	17.1%	14.2%	19%	2.69	1.523
Moodle	di	196	73.5%	10.7%	6.1%	6.6%	3.1%	1.55	1.068
	ii	199	76.4%	9%	5.5%	4.5%	4.5%	1.52	1.086
Google Drive	di	197	49.7%	11.7%	16.8%	11.2%	10.7%	2.21	1.427
	ii	200	59%	12.5%	11.5%	8.5%	8.5%	1.95	1.348
e-mail	di	211	19.9%	13.7%	12.3%	19%	35.1%	3.36	1.553
	ii	205	25.4%	13.2%	15.1%	22.4%	23.9%	3.06	1.528
Zoom	di	196	46.4%	11.2%	15.3%	12.8%	14.3%	2.37	1.512
	ii	203	54.2%	10.3%	12.3%	10.3%	12.8%	2.17	1.488
Skype	di	192	62.5%	13%	7.3%	7.8%	9.4%	1.89	1.360
	ii	197	67%	8.6%	6.6%	7.1%	10.7%	1.86	1.403
Viber	di	222	6.3%	7.2%	9.9%	13.5%	63.1%	4.20	1.246
	ii	217	6%	7.4%	17.5%	18%	51.2%	4.01	1.236
Social networks	di	199	54.8%	9.5%	12.6%	11.6%	11.6%	2.16	1.471
	ii	202	56.4%	10.4%	11.9%	8.4%	12.9%	2.11	1.476
Talking on the phone	di	214	17.8%	10.7%	21.5%	15.4%	34.6%	3.38	1.490
	ii	212	19.3%	10.8%	22.6%	14.6%	32.5%	3.30	1.500

Teachers were directed to choose which type of teaching materials they offer their students when applying direct instruction within online mathematics classes. PowerPoint, Prezi, and other types of presentations were chosen by 72.8% of teachers; text materials were chosen by 83.3% of teachers; additional content and explanations along with text materials were chosen by 75.4% of teachers; text materials for practice were chosen by 75.4% of teachers; video materials were chosen by 71.9% of teachers; audio materials are used by 33.3% of teachers; simulations were chosen by 18.4% of teachers; links to useful content or websites were chosen by 61.8% of teachers; and charts, diagrams, illustrations and similar tools were chosen by 74.1% of teachers.

Also, teachers were directed to choose which type of teaching materials they offer their students when applying indirect instruction within online mathematics classes. PowerPoint, Prezi, and other types of presentations were chosen by 66.2% of teachers; text materials were chosen by 69.7% of teachers; additional content and explanations along with text materials were chosen by 58.8% of teachers; text materials for practice were chosen by 67.1% of teachers; video materials were chosen by 68.8% of teachers; audio materials were chosen by 32.4% of teachers; simulations were chosen by 17.1% of teachers; links to useful content or websites were chosen by 65.8% of teachers; and charts, diagrams, illustrations and similar tools were chosen by 67.5% of teachers. Teachers stated that they still use prepared games and recorded lessons.

DISCUSSION

Given that the method and mode of instruction represent key elements in the effectiveness of the realization of teaching goals, as well as the current importance of online teaching during the COVID-19 pandemic, and the increasingly frequent use of modern technologies in teaching (Fakhrunisa et al. 2020; Kopas-Vukašinović, Mihajlović, Miljković 2021; Singh, Thurman 2019), it was important to examine how teachers perceive the application of direct and indirect instruction in online mathematics classes and with which socio-educational factors their answers are related. Also, our research was particularly focused on determining whether they choose a certain type of instruction more often in the mathematics class and to examine which teaching aids and communication tools they predominantly use for each type of instruction.

When it comes to the perception of the benefits of indirect instruction compared to direct instruction, this research showed that teachers significantly perceive more positive aspects of indirect instruction compared to direct instruction, which corresponds to previous studies that dealt with the issue of indirect instruction in mathematics teaching (Aaron et al. 2015; Warner et al. 2017). In this research, it was shown that as the greatest advantage of the application of indirect instruction compared to direct instruction is that teachers see the preparation of students for independent work and a positive impact on the development of student competencies. Also, to a lesser extent, they perceive that indirect instruction contributes to encouraging students' interests in the content, as well as to a better quality of interaction with students. This is especially important because teachers often state that communication is a problem when implementing online classes (Hohlfeld et al. 2017; Yılmaz et al. 2021), and the application of indirect instruction in this sense can be singled out as one of the potential ways to partially overcome this problem.

In the context of the requirements of applying indirect instruction compared to direct instruction in online mathematics classes, teachers mostly assess that this type of instruction requires greater material and technical resources, more time for lesson preparation, and that its application is generally more complex and represents a greater a challenge for teachers. This is consistent with previous studies that have dealt with the potential limitations and disadvantages of using indirect versus direct instruction in online teaching (Trybus 2013; Warner et al. 2017), which indicated that the realization of mathematical content with direct instruction is simpler, and that the preparation requires much less time. Previous studies also determined that with indirect instruction it is more difficult to get students to think independently, and that this type of work in an online environment requires additional material and technical support, which proved to be particularly problematic when working with students who come from socio-economically disadvantaged backgrounds (Baysu et al. 2019; Özdemir 2016). In addition to the above, teachers – to a significant extent – perceive that the application of indirect instruction in online mathematics classes requires greater methodological competence and a more active role for teachers and students. This also corresponds to the findings of previous studies, which indicate that this type of work requires greater methodological and technical competence (Fakhrunisa et al. 2020; Guerrero-Ortiz et al. 2020). The findings of this research indicate that it is necessary to work on the continuous development of the methodological and technological competences of teachers and to provide them with appropriate material and technical support, in order to apply indirect instructions as efficiently as possible and enable the most active role of students in online mathematics classes.

This research has shown that teachers from urban and rural areas equally perceive the benefits and requirements of applying direct and indirect instruction in online mathematics teaching. It has been noticed that students of a higher educational level (with completed master's and doctoral studies) perceive slightly more intensively that the application of indirect instruction better equips students for independent work, but also that it requires greater material and technical resources. It is possible that they are better informed about the characteristics of the application of indirect instruction in teaching, thanks to the additional education they have acquired, although it should be taken into account that these are small perceptual differences. Also, it was shown that teachers with less work experience perceive to a slightly greater extent that the application of indirect instruction requires a more active role and intensive engagement of students in online mathematics teaching. This may be a consequence of the fact that they completed their studies more recently, in accordance with contemporary educational paradigms, which have increasingly focused on the active role of the student, in contrast to traditional teaching where the student is more passive. Further, less experienced teachers tended to have higher expectations for students' performance, but it should be highlighted that this tendency was slight. It could be expected to a certain extent that the acquired education and work experience would shape the teachers' perceptions when it comes to the application of instructions in online teaching, so those results are consistent with previous findings (Trybus 2013; Warner et al. 2017).

The results of this research showed that approximately half of teachers, compared to other subjects, use direct instruction more often in online mathematic teaching while about a third of teachers equally apply direct and indirect instruction across subjects. Only about 14% of teachers indicated that they use indirect instruction more often than direct instruction in online mathematics classes. It can be assumed that the reason for this result is that teachers perceive the implementation of indirect instructions in online mathematics classes as more complex, as requiring more time, and as requiring additional material and technical resources, which they often do not have (Akram et al. 2022). This suggests that it is necessary to work on strengthening the competences of teachers and to improve the teaching-technological infrastructure in schools.

Regarding the use of tools for communication in online mathematics classes, teachers reported that they predominantly used *Viber*, *Google Classroom*, phone calls, and e-mail for both direct and indirect instruction. To a lesser extent, they also used various online quizzes, *Google Drive*, *Zoom*, and social networks, while they used the other tools to an even lesser extent. It is noted that teachers use a rather wide range of tools, which can be seen from the answers to the open-ended question, where they had the opportunity to state themselves if they used something that was not in the offered answers. The obtained result corresponds to previous studies that found that teachers are trained to use different tools (Akram et al. 2022; Guerrero-Ortiz et al. 2020; Mihajlović, Vulović, Maričić 2021).

When it comes to the application of teaching materials, both in the application of direct and indirect instruction, teachers indicated that they most often use text materials. PowerPoint, Prezi and other types of presentations, additional content and explanations, exercise materials, simulations, and charts, diagrams, and illustrations are somewhat more often used in direct instruction. Links to useful content are more often used in indirect instruction. They use video materials much more often than audio materials in both direct and indirect instruction. This also indicates that teachers use a wide range of teaching materials when applying both types of instruction in online mathematics classes, and that they use a slightly larger number of materials when applying direct instruction, probably because it is easier for them to apply, and they use it more frequently, which is also expected considering previous studies (Fakhrunisa et al. 2020; Guerrero-Ortiz et al. 2020).

CONCLUSION

The main contribution of this research is reflected in the examination of how teachers perceive the application of indirect versus direct instruction in online mathematics classes, as well as what factors could be influences associated with that perception. The general research hypothesis was confirmed. When it comes to practical implications, in accordance with the perception of the benefits and demands that teachers face in this domain, it will be possible to create appropriate educational support and programs for the further development of teachers' competencies in this area. Especially when taking into account the important factors that contribute to the use of indirect instruction in online mathematics classes, the results indicate that this presents a special kind of challenge for teachers and that they tend to apply it somewhat less often than in other subjects. The use of indirect instruction, as this research showed, would especially contribute to overcoming communication problems, which are reported as a frequent problem of online teaching. For this reason it is particularly important to work on providing appropriate material and technical support to teachers.

The examined socio-educational factors – levels of education and work experience – proved to be significantly related to the teachers' perception of direct and indirect instruction. Through future research, it would be useful to examine whether any other internal and external factors are related to teachers' perceptions (e.g. their personal characteristics, school resources) about the application of direct and indirect instruction in online mathematics teaching. Also, it would be significant to study the effects of potential educational programs that could be implemented with the aim of empowering teachers to overcome challenges and to more often apply indirect instructions in online mathematics classes, bearing in mind all the positive sides of this approach, which they themselves are aware of.

REFERENCES

Aaron, Herlost (2015): W. Aaron, P. Herlost, Teachers' perceptions of students' mathematical work while making conjectures: an examination of teacher discussions of an animated geometry classroom scenario, *International Journal of STEM Education*.

Alferi, Brooks, Aldrich, Tenenbaum (2011): L. Alferi, P. J. Brooks, N. J. Aldrich, H. R. Tenenbaum, Does discovery-based instruction enhance learning?, *Journal of Educational Psychology*, 103(1), 1–18.

Appana (2008): S. Appana, A Review of Benefits and Limitations of Online Learning in the Context of the Student, the Instructor and the Tenured Faculty, *International Journal on E-Learning*, 7(1), 207–213.

Aung, Khine (2020): Y. M. Aung, K. M. Khine, A study of the effects of direct instruction and indirect instruction on students' achievement in geometry, *J. Myanmar Acad. Arts Sci.*, XVIII, 9C.

Baysu, Ağırdağ (2019): G. Baysu, O. Ağırdağ, Turkey: Silencing ethnic inequalities under a carpet of nationalism shifting between secular and religious poles, In: P. S. (Eds.), *The Palgrave handbook of race and ethnic inequalities in education*, Palgrave Macmillan, 1073–1096.

Brunstein, Betts, Anderson (2009): A. Brunstein, S. Betts, J. R. Anderson, Practice Enables Successful Learning Under Minimal Guidance, *Journal of Educational Psychology*, 101(4), 790–802.

Cvjetićanin, Maričić (2022): S. Cvjetićanin, M. Maričić, Doprinos primene direktne u odnosu na indirektnu hands-on instrukciju na postignuća učenika u početnom obrazovanju u prirodnim naukama, *Inovacije u nastavi – časopis za savremenu nastavu*, 35(1), Belgrade: University of Belgrade, Teacher Education Faculty, 75–90.

Dean, Kuhn (2007): D. Dean Jr, D. Kuhn, Direct instruction vs. discovery: The long view, *Science Education*, 91(3), 384–397.

DeCaro, Rittle-Johnson (2012): M. S. DeCaro, B. Rittle-Johnson, Exploring mathematics problems prepares children to learn from instruction, *Journal of Experimental Child Psychology*, 113, 552–568.

Dignath, Veenman (2021): C. Dignath, M. V. Veenman, The role of direct strategy instruction and indirect activation of self-regulated learning – Evidence from classroom observation studies, *Educational Psychology Review*, 33(2), 489–533.

Eysnik, De Jong (2012): T. Eysnik, T. De Jong, Does Instructional Approach Matter? How Elaboration Plays a Crutial Role in Multimedia Learning, *Journal of the Learning Sciences*, 21(4), 583–625.

Fakhrunisa, Prabawanto (2020): F. Fakhrunisa, S. Prabawanto, Online Learning in COVID-19 Pandemic: An Investigation of Mathematics Teachers' Perception, *In 2020 The 4th International Conference on Education and E-Learning (ICEEL 2020)*, November 06–08, 2020, Yamanashi, Japan, NY, USA: ACM, New York.

Guerrero-Ortiz, Huincahue (2020): C. Guerrero-Ortiz, J. Huincahue, Mathematics teacher' perceptions and adaptations in developing online classes – ideas for teacher training, *Journal of Physics: Conference Series*, 1702.

Hmelo-Silver, Duncan, Chinn (2007): C. E. Hmelo-Silver, R. G. Duncan, C. A. Chinn, Scaffolding and Achivement in Problem-Based and Inquiry Learning: A Response to Kirschner, Sweller and Clark (2006), *Educational Psychologist*, 42(2), 99–107.

Hohlfeld, Ritzhaupt, Dawson, Wilson (2017): T. N. Hohlfeld, A. D. Ritzhaupt, K. Dawson, M. L. Wilson, An examination of seven years of technology integration in Florida schools: Through the lens of the levels of digital divide in schools, *Computers & Education*, 113, 135–161.

Jones, Southern, (2003): E. D. Jones, T. W. Southern, Balancing perspectives on mathematics instruction, *Focus on Exceptional Children*, 35(9).

Kalyuga, Chandler, Tuovinen, John (2001): S. Kalyuga, P. Chandler, J. Tuovinen, S. John, When Problem Solving Is Superior to Studying Worked Examples, *Journal of Educational Psychology*, 3, 579–588.

Kirschner, Sweller, Clark (2006): P. A. Kirschner, J. Sweller, R. E. Clark, Why Minimal Guidance During Instruction Does Not Work: An Analysus of the Failure of Constructivist, Discovery, Problem-Based, Experiential, and Inquiry-Based Teaching, *Educational psychologist*, 41(2), 75–86.

Kittell (1957): J. E. Kittell, An experimental study of the effect of external direction during learning on transfer and retention of principles, *Journal of Educational Psychology*, 48(7), 391–405.

Kopas-Vukašinović, Mihajlović, Miljković (2021): E. Kopas-Vukašinović, A. Mihajlović, A. Miljković, Stavovi studenata o kvalitetu nastave na daljinu, *Uzdanica*, XVIII/2, 19–33.

Kuhn (2007): D. Kuhn, Is direct instruction an answer to the right question?, *Educational psyhologist*, 42(2), 109–113.

Lee, Anderson (2013): H. S. Lee, J. R. Anderson, Student Learning:What Has Instruction Got to Do With It?, *The Annual Review of Psychology*, 64, 445–469.

Loibi, Rummel (2013): K. Loibi, N. Rummel, The impact of guidance during problem-solving prior to instruction on students' inventions and learning outcomes, *Instructional Science*, 42(3), 305–326.

Maričić, Cvjetićanin, Adamov, Ninković, Anđić (2022a): M. Maričić, S. Cvjetićanin, J. Adamov, S. O. Ninković, B. Anđić, How Do Direct and Indirect Hands-on Instructions Strengthened by the Self-Explanation Effect Promote Learning? Evidence from Motion Content, *Research in Science Education*, 1–21.

Maričić, Cvjetićanin, Andevski, Anđić (2022b): M. Maričić, S. Cvjetićanin, M. Andevski, B. Anđić, Effects of Withholding Answers Coupled with Physical Manipulation on Students' Learning of Magnetism-related Science Content, *Research in Science & Technological Education*.

Matlen, Klahr (2013): B. J. Matlen, D. Klahr, Sequential effects of high and low instructional guidance on children's acquisition of experimentation skills: Is it all in the timing?, *Instructional Science*, 41(3),

Mayer (2004): R. Mayer, Should there be a three-strikes rule against pure discovery learning?, *American Psychologist*, 59, 14–19.

Mihajlović, Vulović, Maričić (2021): A. Mihajlović, N. Vulović, S. Maričić, Teaching Mathematics During the Covid-19 Pandemic – Examining the Perceptions of Class Teachers and Mathematics Teachers, *Nauka, nastava, učenje u izmenjenom društvenom kontekstu*, Jagodina: Faculty of Education, 501–518.

Nifdi, N. I. (2022): *DI vs. di: The Term "Direct Instruction"*. Retrieved in September 2022 from https://www.nifdi.org/what-is-di/di-vs-di.html.

Oladayo, Oladayo (2012): O. T. Oladayo, C. E. Oladayo, Effects of Direct and Indirect Instructional Strategies on Students' Achivement in Mathematics, *African Research Review*, 6(4), 349–361.

Özdemir (2016): C. Özdemir, Equity in the Turkish education system: A multilevel analysis of social background influences on the mathematics performance of 15-year-old students, *European Educational Research Journal*, 15(2), 193–217.

Schmidt, Loyens, Van Gog, Paas (2007): H. G. Schmidt, S. M. Loyens, T. Van Gog, F. Paas, Problem-Based Learning is Compatible with Human Cognitive Architecture: Comentary on Kirschner, Sweller and Clark (2006), *Educational Psychologist*, 42(2), 91–97.

Singh, Thurman (2019): V. Singh, A. Thurman, How many ways can we define online learning? A systematic literature review of definitions of online learning, *American Journal of Distance Education*, 33(4), 289–306.

Stockard, Wood, Coughlin, Rasplica Khoury (2018): J. Stockard, T. W. Wood, C. Coughlin, C. Rasplica Khoury, The Effectiveness of Direct Instruction Curricula: A Meta-Analysis of a Half Century of Research, *Review of Educational Research*, 88(4), 479–507.

Trybus (2013): M. Trybus, Preparing for the future of education – Equipping students with 21st century skills: An interview with Dr. Robin Fogarty, *Delta Kappa Gamma Bulletin*, 80(1), 10–15.

Upu, Buhari (2014): H. Upu, B. Buhari, *Constructivism versus Cognitive Load Theory: In Search for an Effective Mathematics Teaching*. Retrived in September 2022 from https://arxiv.org/ftp/arxiv/papers/2108/2108.04796.pdf.

Warner, Kaur (2017): S. Warner, A. Kaur, The Perceptions of Teachers and Students on a 21st Century Mathematics Instructional Model, *International electronic journal of mathematics education*, 12(2), 193–215.

Yılmaz, Gülbağcı Dede, Sears, Yıldız Nielsen (2021): Z. Yılmaz, H. Gülbağcı Dede, R. Sears, S. Yıldız Nielsen, Are we all in this together?: mathematics teachers' perspectives on equity in remote instruction during pandemic, *Educational Studies in Mathematics*.

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ПЕРЦЕПЦИЈЕ УЧИТЕЉА О ИНСТРУКТИВНОМ ВОЂЕЊУ У ОНЛАЈН-НАСТАВИ МАТЕМАТИКЕ

Резиме: Основни циљ овог истраживања представља испитивање начина на који учитељи опажају захтеве и допринос примене индиректне у односу на директну инструкцију. Поред тога, један од циљева је био и испитати однос социоедукативних варијабли: радна средина, ниво образовања и године радног искуства са начином на који учитељи опажају примену индиректне у односу на директну инструкцију у онлајн-настави математике. Утврђено је и да ли у поређењу са другим предметима, у настави математике учитељи чешће примењују одређену врсту инструкција, као и које наставне материјале и средства за комуникацију примењују приликом употребе директне и индиректне инструкције у онлајн-настави математике.

Ово истраживање је показало да учитељи у значајној мери увиђају позитивне стране примене индиректне у односу на директну инструкцију. Као највеће доприносе примене индиректне у односу на директну инструкцију, виде припрему ученика за самосталан рад и позитиван утицај на развој ученичких компетенција. Када се ради о захтевима примене индиректне у односу на директну инструкцију у онлајн-настави математике, учитељи у највећој мери оцењују да ова врста инструкција захтева веће материјалне и техничке ресурсе, више времена за припрему часа, те да је њена примена генерално комплекснија и да представља већи изазов за учитеље. Показало се да се перцепција карактеристика примене директне и индиректне инструкције у онлајн-настави математике донекле разликује, у зависности од тога да ли су у питању искуснији или мање искусни учитељи, као и тога колики је степен њиховог претходног образовања. Учитељи из градске и сеоске средине у подједнакој мери су свесни

доприноса и захтева примене индиректне у односу на директну инструкцију, те ово може имати позитивне импликације за наставну праксу.

Утврђено је да приближно половина учитеља, у поређењу са осталим предметима, чешће користи директну инструкцију у онлајн-настави математике, док око трећине учитеља подједнако примењује директну и индиректну инструкцију, као и у другим предметима. Свега око 14% учитеља навело је да чешће користи индиректну у односу на директну инструкцију у онлајн-настави математике.

Што се тиче примене средстава за комуникацију у онлајн-настави математике, учитељи су известили да и код примене директне и код примене индиректне инструкције претежно користе *Viber*, *Google Classroom*, разговор телефоном и имејл. Учитељи су известили да користе широк спектар наставних материјала код примене обе врсте инструкција у онлајн-настави математике.

Када је реч о практичним импликацијама, у складу са виђењем доприноса и захтева који се налазе пред учитељима у овом домену, биће омогућено и креирање одговарајуће подршке и програма за даљи професионални развој учитеља, посебно када се узме у обзир значај и улога коју приписују примени индиректних инструкција у онлајн-настави математике и резултат који говори о томе да за њих ово представља посебну врсту изазова, те да су склони да је примењују ипак нешто ређе него у осталим предметима. Употреба индиректних инструкција посебно би допринела превазилажењу проблема у комуникацији, који се наводи као чест недостатак онлајн-наставе.

Кључне речи: директна и индиректна инструкција, онлајн-настава математике, основно образовање, ставови учитеља.