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Croatian Mathematics Teachers and Remote Education During Covid-19: What did They Learn?

Ljerka Jukić Matić[1]

The study reported in this paper aims to show how Croatian lower-secondary mathematics teachers coped with remote education during the lockdown necessitated by the Covid-19 pandemic. The research design refers to the case study of six teachers. On five occasions, the teachers were interviewed about the organisation of their virtual classrooms, forms of assessment, and utilisation of (digital) teaching resources from the beginning of March until the end of June 2020. The study results showed that social parameters were prominent factors in the decision-making of many teachers regarding teaching remotely. For example, the teachers always put students' needs first: they were accessible almost all day to their students, they tried not to overload students and provided daily feedback on their work. In addition, the teachers in the study raised the issue of academic dishonesty in remote education – the digital environment made cheating easier and meant that the usual assessment formats became unfeasible. Although the findings provide insight into the work of teachers during a pandemic, a larger sample would provide generalisations about the changes in workload that mathematics teachers experienced during remote education.

Keywords: mathematics teacher, remote education, teaching, virtual classroom

1 Department of Mathematics, University of Osijek, Croatia; ljukic@mathos.hr.

Hrvaški učitelji matematike in izobraževanje na daljavo v času covida-19: česa so se naučili?

Ljerka Jukić Matić

Namen raziskave je pokazati, kako so se hrvaški učitelji matematike v višjih razredih osnovne šole spoprijeli z izobraževanjem na daljavo med zaprtjem, ki ga je zahtevala pandemija covida-19. Raziskovalni načrt obsega študijo primera šestih učiteljev. Ti so bili od začetka marca do konca junija 2020 petkrat intervjuvani o organizaciji svojih virtualnih učilnic, oblikah ocenjevanja in o uporabi (digitalnih) učnih virov. Rezultati raziskave so pokazali, da so bili socialni parametri pomembni dejavniki pri odločanju številnih učiteljev glede poučevanja na daljavo. Učitelji so, na primer, potrebe učencev vedno postavljali na prvo mesto: učencem so bili na voljo skoraj ves dan, niso jih poskušali preobremeniti in so jim vsak dan posredovali povratne informacije o njihovem delu. Poleg tega so učitelji v študiji izpostavili vprašanje akademske nepoštenosti pri poučevanju na daljavo – digitalno okolje je olajšalo goljufanje in pomenilo, da so običajne oblike ocenjevanja postale neizvedljive. Čeprav ugotovitve omogočajo vpogled v delo učiteljev med pandemijo, bi večji vzorec omogočil posplošitve o spremembah delovne obremenitve, ki so jih učitelji matematike doživljali med izobraževanjem na daljavo.

Ključne besede: učitelj matematike, izobraževanje na daljavo, poučevanje, virtualna učilnica

Introduction

At the beginning of March 2020, the Croatian government closed schools due to the Covid-19 pandemic and introduced remote education as the mode of schooling. In adherence to this, the Ministry of Education and Science (hereafter MZO) directed schools to organise virtual classrooms (MZO, March 2020). Curricular reform has recently been implemented in the Croatian education system, and one of the aims was to bring schools up to date with new technologies (Divjak & Pažur Aničić, 2019). In this process, schools received a significant number of tablets that they could then lend to students for remote learning. Students without internet access were given SIM cards to access virtual classrooms. Television broadcasts, which covered the national curriculum, were created in collaboration with the MZO and volunteer teachers. Primary and secondary students could watch these broadcasts and then communicate with their teachers in virtual classrooms about what they had seen. If teachers could create their lessons and deliver the content and activities in the virtual classrooms, their students would not have to watch the TV broadcasts. The MZO also provided directions on how to make online video lessons using the simplest applications.

Furthermore, the MZO (April 2020) published a document with a set of assessment recommendations. The main focus was on formative assessment, more so than prior to remote education. The key recommendation was to encourage and stimulate students' learning. Nevertheless, the students had to be awarded grades because upper secondary and lower secondary schools finished the school year in June 2020 through remote education. This means that teachers had to organise and conduct some form of summative assessment of students' knowledge.

Although there were many guidelines for remote education, teachers had to deal with many issues on their own, such as organising classroom practice, what resources for teaching and learning they should use, and how to conduct assessments. Similar problems were reported in other European countries such as France, Italy, Germany (Aldon et al., 2021) and on other continents such as Australia (Kalogeropoulos et al., 2021). This paper examines how Croatian lower-secondary mathematics teachers coped with those issues.

Theoretical Framework

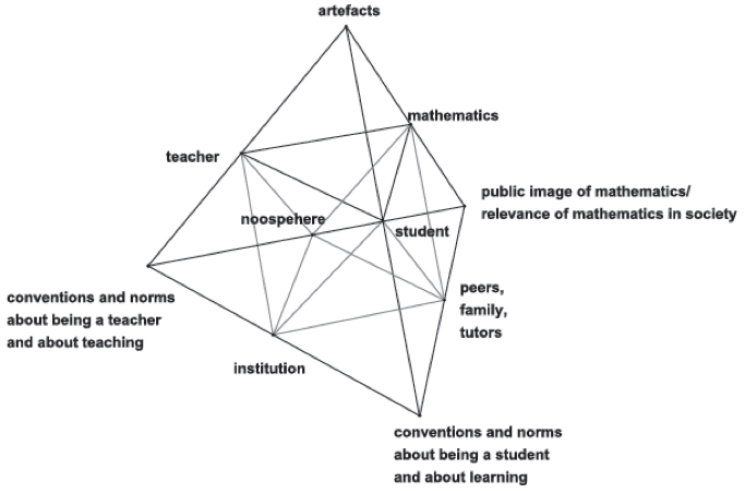
The socio-didactic tetrahedron (SDT) model will be used to examine mathematics classroom practice during remote education as such a model is powerful enough to capture and describe the complexity of educational phenomena in virtual classrooms. Starting from a Vygotskian perspective, Rezat and

Sträßer (2012) re-conceptualised the original didactic triangle (teacher, student, content) by recognising that the connections represented by the sides of the triangle require mediation. Adopting a sociocultural approach, moreover an activity theory (Engeström, 1998), they created a didactic tetrahedron, adding the fourth vertex as the mediating artefact (i.e., the outcome of human activity), made with the precise aim of accomplishing a particular task (Wartofsky, 1979). The artefacts have the role of psychological tools (Vygotsky, 1997), because their central goal is to change student mathematical cognition. Nevertheless, Rezat and Sträßer (2012) prefer the broader notion of artefacts to avoid identifying the notion of a tool with an idea of something material. The mediating artefacts include various resources, from textbooks and digital tools to mathematical tasks and language, because they have the power to shape human activities. In mathematics education, mathematics teaching resources are all the resources developed and used by teachers or students in their interaction with mathematics in and for teaching and learning, inside and outside the classroom (Pepin et al., 2013).

The didactic tetrahedron was further extended by adding social and institutional components at the bottom of it (Rezat & Sträßer, 2012). The bottom vertices of the SDT model are conventions and norms about being a student and about learning, conventions, and norms about being a teacher and about teaching, and the public image of mathematics (Figure 1). Given that these social components are in complex relationships, there are other salient vertices on the bottom edges, such as the institution, the noosphere (the community of teachers and mathematics educators), and peers and family.

Figure 1

SDT according to Rezat and Sträßer (2012)



Each triangular face of the SDT, except the original didactic triangle, can be regarded as an individual activity system in which artefacts serve as mediational means (Rezat & Sträßer, 2012). The teacher's role can be seen as an organiser of students' mathematical activity and is depicted by the triangle *Teacher–Artefacts– Student*. The triangle *Student–Artefacts–Mathematics* represents the student's activity of learning mathematics mediated through resources; the triangle *Teacher–Artefacts–Mathematics* describes the teacher's use of the teaching resources, mediating activity of teaching mathematics, and planning mathematics instruction. Furthermore, the resources lie in a complex and dynamic interplay with the social and didactic parameters that influence the way teachers and students use those resources in the mathematics teaching-learning process.

To investigate how Croatian teachers coped with the demands of remote education, the following research questions were formed: (RQ1) How did lower-secondary mathematics teachers organise classroom practice in remote education and why? (RQ2) How did teachers conduct assessment in virtual classrooms and why? (RQ3) What mathematics teaching resources did teachers utilise during remote education and why?

Method

The design of the study reported in this paper is a case study; purposeful sampling was used. The sample comprised six female lower-secondary mathematics teachers (grades 5 to 8), who were reached through personal connections with the author. Some of the teachers were mentors for preservice mathematics teachers; some had participated in a professional development research project with the author. Acquaintance with the author created a friendly atmosphere in which the participants could engage in open conversations concerning their successes or failures in remote education. Throughout the paper, the teachers will be denoted as Teacher 1, Teacher 2, Teacher 3, Teacher 4, Teacher 5 and Teacher 6.

Yin (2009) claims that the case study method works best when a *how* and *why* question is asked about a set of events over which the investigator has little or no control. A case study research study allows the exploration and understanding of complex issues and proves helpful when an in-depth investigation is required. To answer RQ1, RQ2 and RQ3, I posed questions that asked *how* (Table 1). The organisation of classroom practice and assessment during emergency remote education is portrayed by examining interactions within the triangle *Teacher–Artefacts– Student* (i.e., the teacher as the organiser and

mediator of the resources). The utilisation of mathematics teaching resources also relates to the teacher's mediated activity of doing mathematics and planning mathematics instruction (Rezat & Sträßer, 2012) and is situated within the triangle *Teacher–Artefacts–Mathematics*. In addition, I asked teachers *why* questions to understand the reasons for their choices and decisions better. I aimed to uncover the social and institutional parameters which lie in the background.

Remote education began in the second week of March and lasted until the end of June 2020. The data was collected using online interviews. When direct interaction between researcher and participant occurs through computer-mediated communications (CMCs), Salmons (2015) labels these types of interviews as online interviews and asserts that using videoconferencing allows for an online interview to resemble natural face-to-face communication closely. Online interviews also allow in-depth research. The interviews were conducted on five occasions: the first interview took place in March, the second interview in April, the third interview in May, the fourth interview at the beginning of June and the fifth interview at the end of June (the end of the school year). The same questions were asked in every interview (Table 1). The intention behind this cyclic interviewing was to identify teachers' problems concerning remote education, the development of teaching models and the reasons for using a particular (digital) resource. The interviews were semi-structured, which means that I gave the participants the opportunity to add something if something new happened or if they wanted to share something with me.

Table 1

Questions used in online interviews

Research question	Outline of questions
RQ 1	How do you organise mathematics lessons in the virtual classroom? How do students participate in such lessons? How do you monitor students' logins in virtual classrooms? How do you check students' assignments? Do students ask questions when they do not understand given assignments and how often? Why do you organise classroom practice the way you described? Are you satisfied or dissatisfied with your teaching practice in the virtual classroom? Please explain why. Are you satisfied with students' participation and cooperation? Explain your reasons.
RQ 2	How and how often do you conduct assessments (formative and summative)? Have you encountered any problems related to assessment? Please give details. Why do you assess students in the way you described?
RQ 3	Do you create your own teaching materials, and how? Do you use digital or printed textbooks, and how? Do you use the digital platforms created by the textbook publishers, exchange materials with colleagues, or create video lectures? Explain. How much time do you spend in preparation for remote teaching? Why do you create/do not create your own teaching materials?

After the interviews, the participants emailed the assignments and worksheets they had designed for their students and provided links to video lectures they had created and the forms of digital assessments they used. Teachers also sent examples of students' work. Additionally, they sent screenshots of their virtual classrooms to capture students' activity and communication. Teachers 1 and 2 gave me direct access to their virtual classrooms to experience it myself.

The online interviews were transcribed and analysed. First, all interviews from a single teacher were compared to identify patterns and themes in her teaching practice during remote education. Then I compared the interviews of all the teachers from the same cycle. I looked for similarities and differences among participants. This enabled the identification of common progress for all the teachers. Lastly, other collected data like students' assignments, digital worksheets, or video lectures were examined to justify or discard conclusions.

Results

The study results show that the teachers served as mediators of mathematics teaching resources and organisers of virtual classroom practice during emergency remote education. They gradually changed resource-mediated interaction with students, from using static resources through utilising dynamic digital resources to virtual meetings in some cases. Similarly, the approach to assessment was modified over time. These developments resulted from seeking the optimal model of classroom practice and assessing how a particular change impacted student achievement. Moreover, the teachers' increased familiarity with digital tools and a better understanding of their affordances and constraints also played a significant role in this process. Most of the time, the teachers were guided by what was most beneficial to the students, but they also encountered obstacles that they could not overcome, such as student inactivity or cheating. In the following subsections, I present detailed results for RQ1, RQ2, and RQ3.

Organisation of classroom practice

Mathematics classroom practice in remote education changed over the months regarding the teachers' organisation, mediation of activities, and interaction with students. These changes are recorded in Table 2. The details follow.

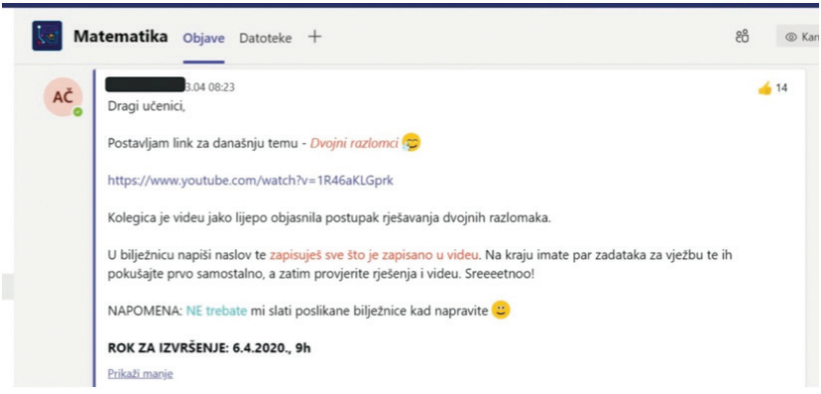
In the first month of remote education, lessons in the virtual classroom consisted of posting assignments for the current math topic. Once a week, the teachers wrote what students had to read or watch and what tasks they had to complete. Interaction with students was established only through homework;

the students sent the completed assignments during the week, and the teachers reviewed them and sent feedback to the students. The teachers explained that many students sent their work irregularly and did not even log in to the virtual classrooms for several days. In some cases, the teachers called and informed students' parents. Teacher 4 attempted real-time communication, but she decided that it was not sustainable for two reasons: first, the system that provided support for the particular social platform was overly busy in the first weeks, so it was not possible to log in to the classroom; second, many students were frequently absent from the virtual classroom.

When remote education continued in the following months, the teachers posted teaching materials in virtual classrooms on the day when mathematics appeared in students' schedules. Assignments had to be completed and handed in by the next mathematics class (for example, see Figure 2). Teachers asked students to 'like' the post as evidence of their presence in the classroom.

> Teacher 2 (April 2020): They have to 'like' my post at some time during the day. Then it means they were in the class that day.

Figure 2
Example of teaching in the virtual classroom as posting materials

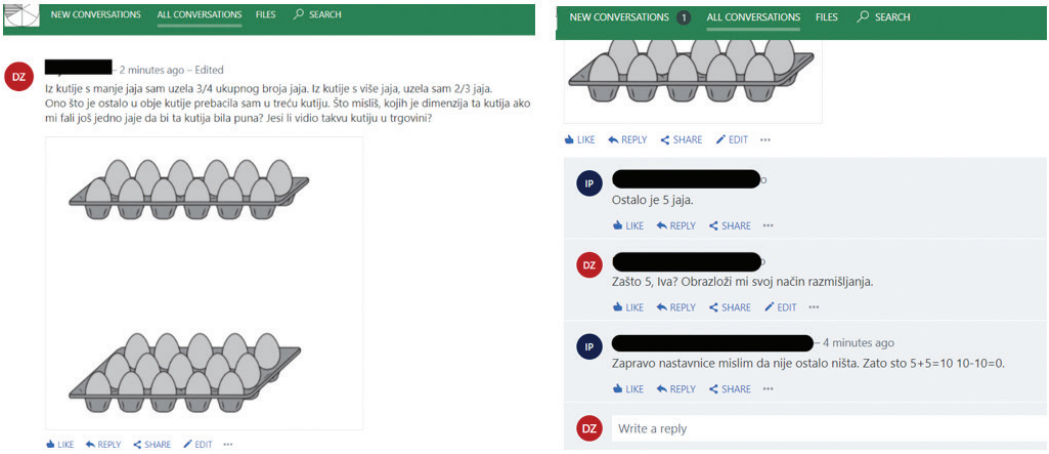


[Translation: I'm posting a link for today's topic - complex fractions. The video explains how to solve these fractions very nicely. Write the title in your notebook and copy everything written in the video. I've given you some exercises; try solving them by yourself, and then check the answers. Good luck. Note: You do NOT have to send photographs of your work. Deadline: April 6th, 2020, 9h]

Teacher 4 decided to rely on TV school for one grade. She taught four different grades (five to eight) and reported that it was too much work to prepare materials for four different lessons for the virtual classrooms. Instead, she adapted her monthly plans to the content in the TV school programmes. This teacher also encouraged students to solve problems by chatting with them in the virtual classroom throughout the day (see example Figure 3).

Figure 3

Example of Teacher 4 encouraging students to solve problems (Grade 5)



a. b.

Translation [a. Teacher: From the box with fewer eggs, I took 3/4 of the total number of eggs. From the box with more eggs, I took 2/3 of the eggs. I transferred what was left to a third box. How big do you think that box is if I need one more egg to make it full? Have you seen a box like that in a store? b. Student: There are 5 eggs left. Teacher: Why 5? Explain your reasoning. Student: In fact, teacher, I think there are none left. Because 5+5=10, and 10-10=0.]

During April and May 2020, most students were active. They sent messages to teachers about mathematical tasks when something was not clear to them. The teachers responded privately to students' inboxes in the virtual classroom or sent messages on Viber. Teacher 1 and Teacher 4 said their students asked only about ICT technology, not mathematics. However, the teachers were available to their students almost all day, and they did not mind when the students sent messages asking something. The teachers concluded that the inability to socialise and go outside activated students around schoolwork, but those who were usually less engaged at school, were also not engaged during this period.

In the last month of remote education, three teachers decided to use real-time communication with students to support learning. However, this was not obligatory, and it was intended only for those who wanted to participate.

> Teacher 4 (beginning of June 2020): I decided to use live meetings for those who wanted to attend.
> Teacher 2 (End of June 2020): I held tutorials once a week for those who wanted to study.
> Teacher 6 (End of June 2020): You know what I did? I painted one wall black for a blackboard, and then I went through what they [the students] didn't understand.

Other teachers explained that they were not set up for this kind of teaching; some did not have the equipment they needed or did not have a suitable working space. However, the teachers noticed that student activity decreased almost to the level it was at the beginning of remote education.

Table 2

Organisation of mathematics classroom practice in remote education

Timeline	March 2020	April & May 2020	June 2020
Teachers	Posting materials in the virtual classroom once a week (all teachers) No deadline for submitting assignments (all teachers)	Posting materials in the virtual classroom according to the school schedule (all teachers) TV broadcasts and problem-solving in a virtual classroom in real-time (Teacher 4) Deadlines for assignments (all teachers)	Posting materials in the virtual classroom according to the school schedule (all teachers) TV broadcasts (Teacher 4) Using virtual meetings as a supplement (Teachers 2, 4, 6) Deadlines for assignments (all teachers)
Students	Students rarely logged into virtual classrooms Mostly passive	Liking the post as evidence of attendance obligatory Students frequently asked questions when they didn't understand Active	Obligatory liking the post as evidence of presence Students asked questions in live meetings when they didn't understand Mostly passive

The teachers generally agreed that remote education in the form of posting materials is not comparable to teaching in a face-to-face classroom situation. Even real-time communication was far from usual classroom interaction, because students would turn their cameras and microphones off. The teachers expressed concern about the depth of the mathematics knowledge students' obtained in circumstances without proper interaction and where their role as the teacher was quite diminished.

> Teacher 3 (April 2020): I am afraid what they [students] will remember next year. They need discussion, challenging their thinking… All things we do in teaching. I am not sure if this [posting materials] qualifies as teaching.
> Teacher 5 (May 2020): I basically post materials. And it is not teaching to me. I had one student, low achieving, telling me 'My mother and I spent the whole afternoon solving your worksheet.' And what's my role here?
> Teacher 1 (End of June 2020): Teaching? Hm... At best, I would call this lecturing. But what about discovery, problem-solving? All those active methods we promote?

Teachers were aware that this type of schooling requires a significant amount of self-study and that their students are not adequately prepared for this. For example, Teacher 5 said that it relates not only to mathematics, 'And it should be borne in mind that students must work for all school subjects in this way'. Other teachers explained they did not want to put more pressure on parents; they were aware that parents had to help students to do the mathematics assignments.

> Teacher 2 (May 2020): These fifth graders… they are still small and dependent on me or their parents. But I was surprised how non-independent seventh graders are!
> Teacher 3 (April 2020): One father called me to complain that he didn't understand what to do. And I said it (the assignment) is for your child, not for you.
> Teacher 4 (Beginning of June 2020): They (the students) were not independent before, and they remained non-independent.

Assessment in remote education

The forms of formative and summative assessment changed during remote education, as can be seen in Table 3. The details are presented below.

In the first months, students sent photos of their work to the teachers, i.e., completed assignments, especially after new content had been introduced, and the teachers gave feedback by writing on the photos or in separate documents. This process continued till the end of remote teaching but to a lesser extent. Providing feedback in this way turned out to be time-consuming.

> Teacher 2 (April 2020): They (students) send me photos of their work on Viber, and then I spend the whole day looking at them, and I write comments on the photos.

> Teacher 4 (April 2020): This feedback…it's time-consuming. They send me photos of their work. And then I sit at my computer the whole afternoon, till midnight, I think…
> Teacher 1 decided not to go over students' work in detail when the remote education entered the second month. She relied on applications with instant feedback. Dispensing with photos increased the amount of free time she had.
> Teacher 1 (April 2020): I dropped the checking of photos [of students' work]. It's an enormous amount of work. I give them [students] a worksheet created in Wiser. They have instant feedback. And using QR codes, they can check their mistakes.
> Teacher 1 (Beginning of June 2020): Yes, I still use Wiser. It functions pretty well. No one complains. Neither students nor parents. And I have time for myself and my family.

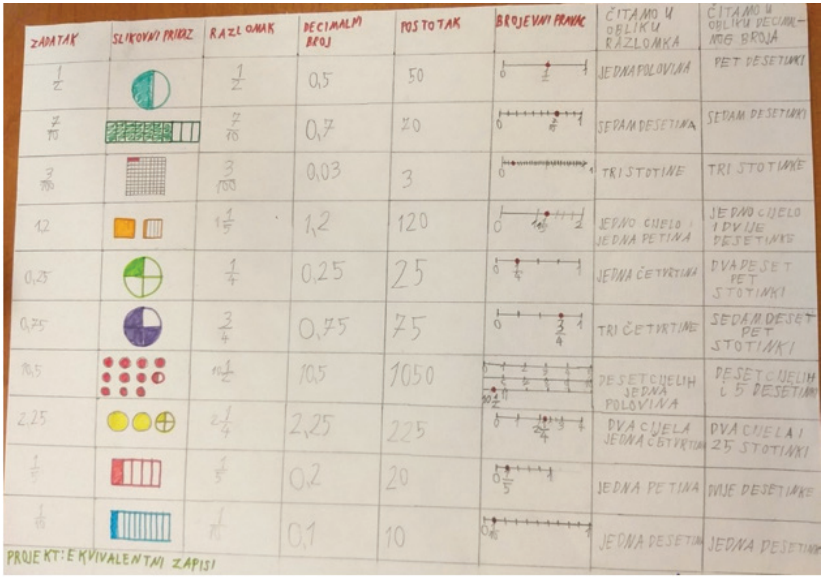
Other teachers also used interactive worksheets; the worksheets gave the teachers and students instant feedback, but the teachers saw this kind of feedback as incomplete. The teachers still asked students to send pictures of solutions to the exercises in the static worksheets to monitor students' progress properly.

Some students used available digital technology for academic cheating and plagiarism. The teachers were aware of that problem; they saw cheating in the assignments that students submitted. Some students would also inadvertently copy mistakes. Sometimes the schoolwork was done by parents or siblings.

> Teacher 5 (April 2020): I saw different handwriting on the photo. And I asked this student who helped him. His father, he said.
> Teacher 3 created a test using a digital tool which limits the test-taking time. She divided the grade into two groups, where the first group took the test an hour earlier than the second group. Most students in the second group finished in two minutes. However, the teacher found out that someone had logged in under a false name in the first group, taken pictures of the tasks and shared them with students in the second group. Other teachers experienced similar situations; therefore, to avoid attempts of plagiarism and cheating, they decided not to conduct written tests or oral assessments via videoconferencing. Instead, the students received assignments that enabled different solutions for each student (see Figure 4).

Teacher 4 (May 2020): Together with my colleagues from history and English, we created an interdisciplinary project for students. It hasn't got great maths in it, but everyone can participate in their own way.
Teacher 6 (May 2020): I decided that students will create mind maps, in some digital tool, for particular topics. And I will distribute topics according to the students' ability.

Figure 4
Example of student's work for the assigned project task Equivalent fractions (grade 5)



Teacher 1 assigned students a real-life project. The project combined geometry with gardening and required students to investigate prices for particular garden items. The teacher received a complaint from a parent about the unsuitability of the task for that school level.

Teacher 1 (May 2020]: Some of the students created beautiful projects. And you can't get a bad mark here. But I received a complaint from one of the parents. Like, this is not appropriate for grade five, and that she will file a complaint against me.

Table 3

Assessment in remote education

Timeline	March 2020	April 2020	May & June 2020
Formative assessment	Feedback given for photographs of students work (all teachers)	Feedback given for photographs of students work (Teachers 2-6) Using digital tools rarely (Teacher 2-6) Using digital tools only (Teacher1)	Feedback given for photographs of students work (Teachers 2-6) Using digital tools regularly (all teachers)
Summative assessment	No tests (all teachers)	Tests in digital environment (all teachers)	Mathematics project tasks (all teachers) Interdisciplinary projects (Teacher 4)

Utilisation of mathematics teaching resources

The teachers' interaction with teaching resources changed significantly throughout remote education (Table 4). In the beginning, the teachers used available resources like video lectures or presentations from colleagues. The textbook was used for practising and homework, and students sent pictures of their solutions to the teachers. As time went on, the teachers learnt how to use various digital tools to create interactive worksheets and adapt the features to mathematics, but they still prepared static documents with exercises. The teachers were informed about various existing digital tools by talking with other colleagues and tried them out as much as possible. However, they used other teachers' video lectures, presentations, or even TV broadcasts for teaching new content.

> Teacher 3 (May 2020): There are publisher's platforms… they [textbook publishers] are constantly informing us. Then new applications... You could sit for 24 hours a day and investigate what is out there.
> Teacher 4 (May 2020): I looked at lots and lots of things. Lots of applications. Now I'm overwhelmed; I have to choose one tool/application/platform and stick to it.
> Teacher 5 (May 2020): We used Socrative a while ago. And I like WordWall. I discovered you can actually write fractions in WordWall, but you have to use Latex. So I had to re-learn Latex (laughs). Last time I used it, I was a student myself (laughs).

The last month of remote education showed that teachers created their own video lectures or presentations to students in real time. They experimented

with and learnt to use a range of digital tools for teaching mathematics content or to create an environment for practising, but they decided to use as few tools as possible. This decision was based on what was in the best interest of the students; they did not want to confuse or overburden students with a variety of digital tools. For geometry topics, teachers decided to use GeoGebra because it was already used in the school and, therefore, familiar to students.

> Teacher 4 (Beginning of June): I decided to use only Office Forms. It's easy for me to create exercises. You can write mathematical symbols easily. And I don't want to overburden students with various new applications. As it is, I have trouble making them work in a virtual classroom.
> Teacher 5 (End of June): At the school level we decided, um, to keep them (applications) to a minimum. There are too many of them, and students get confused if every school subject uses a different application.

Through the interaction with digital tools, teachers discovered that not all of them are mathematics friendly. Namely, specific mathematical symbols cannot be inserted except for subscript or superscript.

Table 4
Teaching resources used in remote education

Timeline	March 2020	April & May 2020	June 2020
Teaching	Someone else's teaching material - video lecture or presentation (all teachers)	Someone else's teaching material - video lecture, presentation, TV school (all teachers)	Own teaching material (all teachers)
Practising/ Homework	Textbook (all teachers)	Own interactive (all teachers) and static worksheets (Teachers 2-6)	Own interactive (all teachers) and static worksheets (Teachers 2-6)

In the interviews, the teachers said they worked more than 12 hours a day at the beginning of the remote education, which included sourcing materials, adapting materials, answering students' questions using a communication application, and checking students' work. The amount of time needed to create teaching materials decreased towards the end, but they still spent more time working than on a regular school day.

Discussion and Conclusion

The study reported in this paper aims to show how lower-secondary mathematics teachers organised classroom practice, conducted assessments in virtual classrooms and used teaching resources during the emergency remote education.

Organisation of classroom practice, assessment, and utilisation of resources

In the virtual classrooms examined in this study, teaching was impersonal most of the time. Mathematics was meditated to students mainly through mathematics teaching resources and in indirect interaction with the teacher. Students were not actively engaged when teachers mediated mathematics content, but sometime later. It seems that teachers felt that there was a discrepancy in their role as teachers before and during the pandemic; they saw themselves as just being providers of mathematical activities in the virtual classroom, which three teachers tried to overcome by providing real-time teaching in the last month of remote education. Teaching which lacks direct face-to-face communication between students and teachers can hinder teachers' ability to assess students' understanding and reasoning in a meaningful way. For mathematics teaching to be effective, teachers need to listen to and interpret students' actions (talk, gestures, and writing) and thinking while students make decisions (Jacobs et al., 2010; NTCM, 2014). This means that it is important to know students' reasoning, difficulties, mistakes, and misconceptions (Swan, 2001). The lack of face-to-face communication might not be a problem for a well-designed online course, but it turned out to be a problem in ad hoc virtual classrooms where the teacher tried to replicate a regular classroom.

Assessment in virtual classrooms focused on formative assessment, providing continuous feedback to students on their comprehension and understanding of mathematical content during remote education. Teachers in the study based summative assessment on small projects, which enabled the authenticity of students' work. The lack of personal interaction between students and teachers in the teaching process influenced student activity. Such learning of mathematics required students to be more independent in virtual classrooms than in regular classrooms. Also, the assessment teachers designed emphasised students' responsibility for the process and product of self-learning. Although we do not have enough data to make a strong inference about the quality and depth of students' learning, the teachers' statements indicate that many students had a hard time with the self-learning of new mathematical content. In a study

of teachers' perceptions of students dealing with emergency remote education, Jelińska and Paradowski (2021) reported that older students (higher secondary and tertiary levels) could better adapt and take control of their learning because they have better-developed self-learning strategies, unlike younger students.

It is important to point out that effective mathematics teaching reflects the quality of students' learning, especially knowledge retention and transfer (NCTM, 2014). Even with teachers' best intentions to design a quality teaching environment, it remains to be seen whether classroom practice in emergency remote education was effective in the long run, because creating productive instructional episodes by mobilising various resources remains problematic in regular classroom practice (Jukić Matić, 2019). Of all the resources used by teachers over this period, such as video lessons, voice-over presentations, digital and non-digital worksheets, the textbook was used the least. While mathematics textbooks are the most used teaching resource in mathematics education worldwide (e.g., Fan, 2013), as is also the case in Croatia (Glasnović Gracin & Jukić Matić, 2016), it seems that their role diminished in online lessons. The study results showed that other kinds of resources became more prominent but that creating these resources for virtual classrooms took more time than for regular lessons.

Influence of social and institutional parameters

The study's findings showed the significant influence of the bottom of the SDT, social and institutional parameters, on mathematics remote education during the COVID-19 pandemic. The conventions and norms about being a teacher and about teaching had an essential role in shaping teaching in the virtual classroom. Moreover, these norms impacted many teacher decisions. Teachers' awareness that some digital tools are incompatible with mathematics (e.g., the inability to write certain mathematical symbols) made them look further for tools/applications that could overcome these difficulties. That placed the teachers in the role of learners. The norm about being a teacher implies continuous learning (Timperley et al., 2007).

Nevertheless, having to take on this role increased the amount of time needed to fulfil their work obligations. Further, the communication between the teachers and their students happened almost daily, designed to give individual feedback. These teachers spent a great deal of time checking photos of students' work, even though providing such feedback is time-consuming. It seems that giving feedback was also important to teachers in other countries during emergency remote education (Aldon et al., 2021; Kalogeropoulos et al., 2021). To avoid cheating and to evaluate students' knowledge fairly, the teachers

in the study designed assessment tasks that differed from student to student. This kind of assessment is also time-consuming.

Furthermore, the fact that the teachers made themselves available to respond to students' questions reflects the norm of being a teacher (McClain & Cobb, 2001). All the above emphasises a teacher's role as a facilitator who proactively supports students and their learning during remote education. Studies examining teachers' workloads during the pandemic have shown that remote education has increased a teacher's sense of responsibility for student achievement and their job-related stress levels (e.g., Collie, 2021; Jelińska & Paradowski, 2021).

Some students did not perceive this mode of education as compulsory, carrying with it certain obligations and responsibilities, because in the first and last month, many were not active in the virtual classrooms. The students' obligations and rights, namely social norms, are usually established at the beginning of the school year and, as such, form classroom culture (Wood, 1994). The norms about being a student in a mathematics classroom had been established and renegotiated during remote education, but it seems that the impersonal nature of interaction with teachers meant that the new norms were difficult to uphold. Some students engaged in academic dishonesty (e.g., cheating in tests, copying homework or plagiarism), and it seemed that academic integrity was more difficult to maintain in an online setting. Academic dishonesty is not a foreign concept for Croatian students. At the primary school level, recent research conducted by Ristić Dedić et al. (2017) showed that more than 30% of eighth-grade students said that they copied other students' homework, while almost 50% stated that they rarely do so. However, this would indicate that academic dishonesty is fairly widespread among the surveyed primary school students as even the response 'rarely' suggests instances of copying.

The noosphere served as the support to the mathematics teachers, until they became skilled with various digital tools. Teachers shared materials with their colleagues more than they did before the pandemic, and they kept one another informed about new digital tools and their possibilities. Making use of others' materials and suggestions alleviated teachers' workloads. Various research has stressed the importance of collegial relationships for teacher professional growth and development (e.g., Retallick & Butt, 2004). Moreover, collegiality helps teachers cope with uncertainty and complexity and respond effectively to changes (Hargreaves, 2000), which was certainly in evidence during the period of remote education.

The Ministry of Education instructed schools to organise remote education so as to resemble regular school life as much as possible. The schools

were left to determine the features of the virtual classroom they would use; as a consequence, putting some teachers in ICT environments that were not mathematics-friendly. This highlights the role of institutions in the SDT model. The parents also had a significant role in emergency remote education. Teachers in the study estimated that their students, aged 11-14 years, were not sufficiently independent to meet school and mathematics obligations alone and that the input of many in the teaching-learning process was significant. Although educational literature promotes the partnership between parents and teachers for students' mathematics success (e.g., Patall et al., 2008; Jay et al., 2018), this partnership is of a different nature than in distance education during a regular classroom in a pandemic. It could be argued that some parents had more to do with schoolwork in virtual classrooms because they had to become substitute mathematics teachers at home.

Limitations and further directions

One limitation of this study is examining remote education only from the teachers' perspective and neglecting the students' perspective. However, given the conditions at the time, including lockdown and social distancing, this was not an option. A second limitation is connected with the number of teachers. A greater sample would provide generalisations about the changes in workload that mathematics teachers experienced in remote education. This study also revealed some hidden assumptions of remote education, which emerged as secondary results. The first assumption was that teachers had access to good ICT equipment and a good internet connection. If a teacher relied on the TV school and reduced their activity in virtual classrooms to a minimum, then they had real-time online meetings in virtual teacher lounges with school principals. The second assumption was that teachers had adequate space at home to prepare and conduct remote teaching, for instance, creating video lectures or recording their voice on presentations. The third assumption was that teachers who taught in virtual classrooms were relatively ICT literate and possessed a sound knowledge of online pedagogy in order to create successful virtual learning environments. However, is it reasonable to expect all of these things from Croatian teachers, or indeed any teachers? Given the variety of digital tools that teachers learnt to use, future research could address and assess teachers' pedagogical design capacity, meaning ability to perceive and mobilise mathematics teaching (digital) resources to create productive instruction episodes (Brown, 2009).

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Biographical note

Ljerka Jukić Matić, PhD, is an assistant professor in the field of didactics of mathematics at the Department of Mathematics, University of Osijek, Croatia. Her research interests include the role of curriculum resources in the teaching and learning of school mathematics, the professional development of mathematics teachers in education, and the development of mathematical creativity in school children.