May 22nd 2020

RE: 2nd Edition of the Springer book

The Mathematics Teacher in the Digital Era:
An International Perspective on Technology Focused Professional Development.

Dear Mario,

We are cordially inviting you to consider contributing your expertise in mathematics education to the 2nd edition of the above title, the 1st edition of which has the accolade of being the book with the highest number of chapter downloads (28,000) in the series *Mathematics Education in the Digital Era*, published by Springer. (https://www.springer.com/gp/book/9789400746374).

The broader aim of the Mathematics Education in the Digital Era series (MEDEra) is to explore the ways in which recent digital technologies support mathematics teaching and the learning of young people who are growing up in an increasingly technological world. A prevailing issue concerns the initial education and lifelong professional learning of teachers of mathematics to enable them to realise the affordances of educational technology for mathematics. This second volume aims to extend and enhance the ideas presented in the first edition through invited contributions in the form of individual chapters containing a blend of research articles and descriptive texts.

We are particularly interested in chapters that address or refer to the following themes:

- Teachers' current technology-mediated classroom practices from kindergarten to university levels.
- Outcomes of technology integrations (and medium and large scale) at the classroom level, focussing on the role of the teacher.
- Examples of the design and implementation of programs (about and involving technology) for mathematics teacher professional development in different countries (pre-service and in-service).
- Mathematics teacher development projects (concerning technology).
- Design and selection of tasks by teachers as part of wider resource systems.
- Design, use and evaluation of new technologies for teaching mathematics, to include online and blended environments.
- Interactions among teachers with technologies in communities of practice.

We would welcome chapters that feature comparative studies between countries on any of the above themes.

We are inviting you to collaborate with us on this project by contributing a chapter. Should you accept this invitation, we would like you to send (by email) a tentative title and a 600 word outline for your proposed chapter by June 30th 2020. It would be helpful if you could inform us if you intend to submit a chapter proposal as soon as possible.

Following this, we will review the chapter proposals in early July and inform you whether we would like you to submit a complete chapter of 15-20 pages by November 30th 2020. We will also send full details of the **peer-review process**, which will be conducted by us all.

Please use the following contact email for correspondence: a.clark-wilson@ucl.ac.uk.

If presently you do not have time to participate in this project, we will be grateful if you would suggest some other colleagues who work in the named areas.

We appreciate your consideration of this invitation and hope to hear from you soon!

Warm regards,

Alison Clark-Wilson Ornella Robutti Nathalie Sinclair

Co-Editors of *The Mathematics Teacher in the Digital Era: An International Perspective on Technology Focused Professional Development (2nd Edition)*

Mathematics Education in the Digital Era

Alison Clark-Wilson
Ornella Robutti
Nathalie Sinclair *Editors*

The Mathematics Teacher in the Digital Era

International Research on Professional Learning and Practice

Second Edition

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Contents

The Abrupt Transition to Online Mathematics Teaching Due to the COVID-19 Pandemic: Listening to Latin American Teachers' Voices

Mario Sánchez Aguilar, Danelly Susana Esparza Puga, and Javier Lezama

Abstract This study explores the way in which a group of Latin American mathematics teachers cope with the abrupt integration of digital technology into their mathematics teaching caused by the COVID-19 pandemic, which began in 2020. The study gives *voice* to mathematics teachers who have experienced first-hand the digital transition caused by the pandemic. Through an open survey of 179 mathematics teachers from different Latin American countries, teachers are asked how they adapted their mathematics lessons to the new context, how they felt in this transition, and if they received associated material support or guidance. The questionnaire recognises teachers' knowledge and experience by asking them about suggestions or recommendations to other colleagues who are experiencing the same digital transition. This study contributes to broadening our knowledge about the way mathematics teachers deal with the integration of technology in their teaching practices, particularly in situations where such integration is imposed.

Keywords Online mathematics teaching · Digital migration · Latin American teachers' voices · COVID-19 pandemic

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1 Introduction

The infectious COVID-19 disease is caused by the virus SARS-CoV-2 and can lead to serious respiratory complications, and even death. The first COVID-19 outbreak was first identified in Wuhan, China, in December 2019. Since then the virus gradually spread around the world, including Latin America, the region where the teachers who participated in this study live. The global COVID-19 pandemic brought about profound changes in the social, political and economic dynamics of nations around the world. In the particular case of school mathematics instruction, many teachers experienced an abrupt transition from a face-to-face teaching setting to a completely different scenario of remote instruction based on the use of digital tools. However, such a transition is not without complications. It is possible to hear diverse stories from teachers expressing the difficulties resulting from this transition. Several of those difficulties are related to the implementation of technological elements in their mathematics teaching, which in many cases is carried out under adverse conditions.

The digital transition also evidenced a heterogeneous digital culture reflected in a diversity of teaching practices and competencies. Some mathematics teachers seemed to be better prepared for the implementation of digital tools in their teaching practice. This is mainly due to the access and previous experiences with the use of digital tools in mathematics that these teachers had (Csachová & Jurečková, 2020).

This digital transition led the mathematics teachers to make improvements—not without difficulties—at the personal, collective and institutional level that would allow them to build teaching solutions to continue the educational act. Training themselves in the use of digital tools, improving the production of digital materials, designing ways to promote and evaluate mathematical learning in virtual settings, as well as trying to rescue those students lost during the digital transition (Chirinda et al., 2021).

Research on mathematics teacher education and development has studied the limitations, constraints and obstacles related to the implementation and adoption of digital technologies into mathematics teaching (e.g., Abboud-Blanchard, 2014; Thomas & Palmer, 2014); however, such studies were not developed under the extraordinary conditions experienced as a result of the COVID-19 pandemic. In this particular scenario, the implementation and adoption of digital tools was suddenly imposed on many teachers in regions of the world where the economic and social conditions were not always optimal. The study reported in this chapter expands the discussion on the constraints of, and obstacles to, implementing digital technologies in mathematics teaching, by exploring the way teachers cope with the abrupt integration of digital technology (mathematical software, video-conferencing software, learning management systems, YouTube, among others) into their daily teaching practices due to the COVID-19 pandemic.

The aim of this study is to explore the way in which Latin American mathematics teachers deal with the abrupt implementation of digital technology in their teaching practices. The study gives *voice* to mathematics teachers in order to know more

about not only how they deal with the digital implementation, but also their feelings about this digital transition caused by the COVID 19 pandemic and the support they have received to navigate it. The study contributes to broadening our knowledge about the way mathematics teachers deal with the integration of technology in their teaching practices, particularly in situations where such integration is imposed upon them.

2 On the Notion of Teachers' Voice

The notion of *teachers' voice* arises as a critical response to a type of educational research focused on producing knowledge about teachers and their work, but which paradoxically tended to ignore the teachers' inquiries and lived experiences of their own teaching practice as a possible source of knowledge (Atkinson & Rosiek, 2008). Thus, the interest in giving teachers a *voice* arises from the need to produce research knowledge that considers the experiences lived by teachers, the teaching contexts that give rise to their voices, and the different things they may have to say about teaching and learning (Hargreaves, 1996).

The notion of "teachers' voice" has been used and conceptualised in different ways within the field of teacher education research. For instance, in the case of mathematics teacher education, the development of the teachers' own voice has been associated with the evolution of a professional identity as a mathematics teacher (Brown & McNamara, 2011). It has also been used as a tool to articulate critical and dissenting thoughts in connection to the teaching of mathematics (De Freitas, 2004). In educational research where the notion of teachers' voice has been most widely used, there are also varied and nuanced definitions. For instance, Frost (2008) defines teacher voice as "the views, experience, and perspective of teachers on educational policy and practice" (p. 347), while Hargreaves (1996) defines it as "the place teachers occupy and the role they play in school restructuring and reform" (p. 12). Another definition is provided by Gyurko (2012): "the expression by teachers of knowledge or opinions pertaining to their work, shared in school or other public settings, in the discussion of contested issues that have a broad impact on the process and outcomes of education." (p. 4).

In this study the notion of teacher's voice is understood as the values, beliefs, emotions, practical experiences, and perspectives of teachers about their work alongside the degree to which those elements are considered, included, listened to, and acted upon when important decisions and changes are being made in the educational context where teachers carry out their work. Some authors have argued about the importance of referring to the teachers' *voices* (in plural) instead of the "teacher's voice" as a representative and unifying entity (e.g., Atkinson & Rosiek, 2008; Hargreaves, 1996). Referring to *teachers' voices* emphasises the individuality and even dissonance of such voices, which have been shaped "by immense variations in the context in which they teach" (Atkinson & Rosiek, 2008, p. 177).

Before introducing our methods to elicit the voices of the teachers in this qualitative study, we present a brief review of previous research focused on analysing the obstacles and constraints that mathematics teachers experience when integrating digital technology into their teaching. To promote the articulation and continuity among research studies, we frame our study by focusing on relevant research published in the first edition of this book (Clark-Wilson et al., 2014).

3 Previous Research on Obstacles and Constraints to Digital Technology Integration

The research focused on analysing the obstacles and constraints that mathematics teachers experience when integrating digital technology into their own teaching is well represented in the first edition of this book (Clark-Wilson et al., 2014). In particular, two chapters address this problem from different perspectives (Abboud-Blanchard, 2014; Thomas & Palmer, 2014).

The study by Thomas and Palmer (2014) reviews research that identifies obstacles to, and constraints on, secondary teachers' implementation of digital technology into their mathematics teaching. Based on the results of a longitudinal study in New Zealand, the researchers identify the following obstacles and constraints to technology use (particularly computers and calculators):

- Time constraints (e.g., the time needed to become familiar with the technology).
- Access to technology (e.g., unavailability of calculators, computers and software).
- Lack of training in the use of technological tools.
- Lack of confidence in the use of technological tools.
- Government and school policies.

Thomas and Palmer (2014) point out that the obstacles and constraints identified can be divided into extrinsic factors (such as the lack of access to technological resources) and intrinsic factors (such as the lack of confidence in the use of technological tools in teaching mathematics). The authors also indicate that their results coincide with the factors influencing teacher adoption and implementation of technology in mathematics teaching identified by other researchers (e.g., Forgasz, 2006; Goos, 2005).

The approach followed by Abboud-Blanchard (2014) to the study of the integration of digital technology (such as dynamic geometry software and online electronic exercise portals) into mathematics teaching is different from that taken by Thomas and Palmer (2014). Based on a synthesis of three studies developed in France, the researcher identifies common characteristics in terms of common responses to shared constraints related to the integration of technology by ordinary mathematics teachers. By *ordinary teachers* she refers to "teachers who are not technology-experts and who are not involved in experimental projects" (Abboud-Blanchard, 2014, p. 298).

Abboud-Blanchard (2014) acknowledges that the practices analysed in the three considered studies are shaped by the socio-educational and institutional conditions in which teachers develop their job, as well as by their personal trajectories. Nevertheless, she claims that it is possible to find regularities in the teachers' responses reported in these studies:

> These regularities seem to be directly related to the common constraints and difficulties that teachers face when using technology and the way that they handle them […] these are choices (though certainly related to the personal component) that reflect how teachers invest the few options left, given the institutional and social constraints. (p. 304)

Abboud-Blanchard (2014) analysed the teachers' common responses to the shared constraints into three axes, which are the:

- *Cognitive axis*. How to simultaneously teach mathematics and use technology in class (related to the mathematical content taught with technology)
- *Pragmatic axis*. How to teach mathematics in new teaching environments (related to what the teacher does and says when implementing a classroom situation using technology)
- *Temporal axis*. How to manage the time for teaching and learning when using technology (related to different aspects of time management)

There are some similarities in the research findings reported by Abboud-Blanchard (2014) and Thomas and Palmer (2014). For example, both researchers coincide in pointing to teachers' lack of confidence in using digital technology as a constraint of, or an obstacle to, its implementation in the teaching of mathematics alongside a (lack of) time.

In our study we also focus on the way teachers implement digital technology in their mathematics teaching and the obstacles they find to doing so; however, our study maintains important differences with its predecessors. Firstly, we not only consider the implementation of digital technologies typically associated with the teaching of mathematics (such as calculators or dynamic geometry software), but we also consider the implementation of more general digital technologies such as videoconferencing software, learning management platforms, and YouTube, among others.

Another important difference with previous studies is the context and conditions in which the process of implementation of digital technologies takes place. The COVID-19 pandemic forced mathematics teachers to abruptly implement the use of digital tools in their teaching, regardless of their institutional and social constraints and conditions. This study explores how mathematics teachers navigate the early stages of this difficult and demanding implementation process.

Finally, another significant difference between this study and those reported by Abboud-Blanchard (2014) and Thomas and Palmer (2014) is the fact that this study does not directly observe the teacher's practice (the "pragmatic axis" according to Abboud-Blanchard, 2014). As explained in more detail in the next section on the research method, this study approximates mathematics teachers' practices through their self-reports captured through an open questionnaire, which were analysed using a grounded (inductive) approach. Consequently, our research enriches the inquiry of the limitations, constraints, and obstacles related to the implementation

and adoption of digital technologies into mathematics teaching. In particular, this study aims to broaden our understanding of the way in which mathematics teachers act and feel when faced with a phenomenon of abrupt implementation of digital technology in their own teaching.

4 Method

This chapter and the study that it reports were developed under lockdown during the COVID-19 global pandemic. This section describes the method that was followed to develop the study under these conditions, beginning with a brief description of the pandemic context in which it was developed.

4.1 Context of the Study

The global COVID-19 pandemic triggered social and economic crisis around the world. Among the effects of the pandemic is the global digital migration of thousands of teachers and students from face-to-face mathematics instruction to online mathematics instruction. This research took place during the first months of this massive digital migration.

Although with different issuing dates, the institutional orders to begin distance instruction in Latin American countries took place during the first semester of 2020. The abrupt nature of the digital transition made evident the heterogeneity between, and within, Latin American countries in terms of quality of internet connections, access to digital tools, and digital competencies. Consequently, students and teachers in geographically distant or isolated regions experienced greater difficulties in continuing with their mathematics instruction. Even in large urban areas in Latin America where access to the internet and digital tools is more widespread, access to online instruction was not guaranteed for all students. The socio-economically disadvantaged students faced greater obstacles to staying connected, due to a limited access to digital resources exacerbated by the economic crisis that accompanied the pandemic. In the more severe cases, students and teachers from some particularly underprivileged areas of Latin America were simply detached from the educational system—interrupting their mathematics instruction completely.

4.2 Study Participants

We were interested in hearing the voices of Latin American teachers about their experience teaching mathematics in this new context of instruction. An opportunity sample was constituted by sending email invitations to approximately 800 Latin

American mathematics teachers, asking them to voluntarily answer a questionnaire (see next section) related to the digital transition of their teaching practice due to the COVID-19 pandemic. Despite the pressing moment in which the questionnaire was sent, 179 teachers agreed to answer it.

The teachers who answered the questionnaire were contacted through two main means. On the one hand, teachers associated with the social network *DocenMat* (a regional social network of mathematics teachers interested in mathematics education; see https://docenciaenmatematicas.ning.com) were contacted and invited to answer the questionnaire; on the other hand, teachers who had graduated from an online postgraduate program in mathematics education were invited to participate and to use their personal networks to extend the invitation to other teachers. Although the online postgraduate program is located in Mexico City, it receives in-service mathematics teachers from different Latin American countries (see Gómez-Blancarte et al., 2019).

The 179 teachers who responded were men and women from Argentina, Chile, Colombia, Mexico and Uruguay. One hundred forty-nine of these teachers reported working in public schools and 28 in private schools (two teachers declined to provide this information). The participating teachers work at the university level (45), upper secondary level (66), primary level (44), and some of them (24) declared that they work at more than one educational level, without stating the levels. All the schools where these teachers work are located in urban and semi-urban areas, except for six teachers who through their responses stated that they work in rural areas.

4.3 The Questionnaire

Due to its potential for gathering information from large audiences, and due to the mobility and social distancing restrictions imposed by the COVID-19 pandemic, we designed an online questionnaire. It was constructed with an empathetic spirit that invited teachers to express their views. The questionnaire (see Appendix 1) was designed to elicit:

- general contextual questions not directly related to mathematics instruction (questions 1, 2 and 3).
- how the teachers were adapting their mathematics lessons to the new context (questions 7, 8 and 9)
- how the teachers felt about this transition and if they received related material support or guidance (questions 5, 6 and 10).
- the knowledge and experience of the teachers by asking about the suggestions or recommendations that they would make to other colleagues who are in the same digital transition (question 11).

Of special relevance to the focus of this book are the questions related to teachers' adaptations of the mathematical content and its approach to the virtual format, the time this took and the format of the resulting lessons.

4.4 Implementation of the Questionnaire

The final questionnaire was distributed to the participating teachers using the survey administration software Google Forms. This software automatically anonymised the responses and organised them in a spreadsheet, which facilitated the capture and subsequent analysis of the empirical data. The questionnaire was distributed between May 22 and June 3, 2020 a few weeks after the teachers had begun the digital migration, to gather data on their emotions and experiences at this early stage of the process of transformation.

4.5 Analysis of the Teachers' Responses

The analysis process for the teachers' responses was different for each type of question. In the case of questions that were answered with a "yes/no" or with a small set of possible answers, a frequency count of the answers expressed by the teachers was made (i.e., questions 1, 6 ad 9).

The open questions, designed to give voice to the mathematics teachers, were subjected to open coding (Saldaña, 2013). As mentioned before, this type of questions not only ask teachers about the adaptation of their mathematics lessons to the new context, but also ask about the way they feel and the support they have received during the transition (i.e., questions 7, 8 and 10). This open coding enabled regularities in the teachers' answers to be found, which could then be grouped into categories. In a first level of coding, similar keywords or phrases were identified within the teachers' responses and a code was assigned to each, which would enable later categorical grouping. For example, in several responses, teachers reported difficulties they were experiencing related to the digital transition. The utterances in which the teachers expressed such difficulties were coded according to their nature (see Table 1). These codes were subsequently grouped into the category of *implementation obstacles* that teachers face during the digital transition caused by the COVID-19 pandemic.

5 Results

In this section we present the results of the analysis of the teachers' responses to the open questions. The results are organised into six categories: *implementation obstacles*, *time needed for adapting the lessons*, *teachers' lessons descriptions*, *implementation of digital tools*, *teachers' emotions*, and *teachers' suggestions and recommendations*. These categories represent different aspects of what teachers did and felt during the abrupt digital transition that their mathematics teaching work had undergone. The categories are illustrated with extracts from the teachers' responses to the questionnaire.

Table 1 Codes and responses that constitute the category of implementation obstacles faced by teachers

Code and number of respondents	Code description	Sample response
Lack of training (92)	Teachers stated that they did not receive training from the authorities of their educational institutions	R127: **I did not receive advice**. Only between colleagues and friends from the school. Remains the same until now. Then I resorted to what was available on YouTube
Lack of computer equipment (8)	Teachers stated that either their students or themselves did not have the necessary computer equipment to teach or study online	R147: I have had great difficulty adapting myself to the virtual mode, and in acquiring the appropriate equipment to perform it (**I have old and obsolete computer equipment**)
Limited access to the internet by students (69)	Teachers declare that, for various reasons, students have limited or no access to the internet	R117: As the students come from a rural community, **they do not have unlimited access to the internet** and they do not have computers. We generally work by WhatsApp
Deficiencies in the teachers' quality of internet services (97)	Although most teachers had internet access, some commented that the quality of their service was poor	R131: The internet service is average. **I have had some problems due to the total loss of the internet signal**, one of them precisely on the day of the lesson

5.1 Implementation Obstacles

As mentioned before, in the teachers' responses it was possible to identify obstacles that they faced when trying to migrate from face-to-face mathematics instruction to online mathematics instruction (see the sample responses and number of respondents in Table 1). In particular, two types of obstacles were identified. The first of these is the *lack of training*, which refers to the lack of support that teachers received from the authorities to train themselves in the use of digital tools.

R35: We were not given assistance and I had to do some research around the handling of online whiteboards.

R108: I did not receive support, but with my colleagues we supported each other.

The second type of obstacle refers to the *lack of internet access*. Teachers refer to how the lack of internet access—for both their students and themselves—hampered the development of their courses.

R67: It is very difficult to do an online class as such, because in the environment where I work, students do not have enough financial resources to be in virtual lessons.

R167: I have internet access, but the access to the service is intermittent. There are times of the day where the connection does not allow you to work smoothly.

R74: The internet access in my community is null, so I limit myself to working on WhatsApp.

There were eight teachers who identified the lack of access to adequate computer equipment as an obstacle to implementing their mathematics lessons online (for instance, see sample response R147 in Table 1).

5.2 Time Needed to Adapt Mathematics Lessons

Teachers wrote about the time needed to adapt their mathematics lessons to the online modality. A recurring complaint from teachers was that they had to invest much more time preparing their teaching materials for the online setting than the time needed for planning face-to-face lessons (91 of the teachers reported this). However, there were a few teachers (24) who stated that they did not need much time to plan their lessons, due to their previous experiences of using digital tools.

R72: It takes me a long time. Because I look for activities and also explanatory videos on the topic. If I calculate the time, it would be triple the time I did before. Practically I am working for most of the day.

R149: I changed the topics to start with the simplest ones. It takes a lot of time, since it not only involves preparing each activity in a digital format and explaining it in a way that the student can understand it, but also involves learning to use the [digital] tools and provide feedback to each student.

R90: I do not need much [time] because I constantly use technology in my lessons.

5.3 Teachers' Lessons Descriptions

The analysis of the teachers' descriptions of their own mathematics lessons allowed us to identify a number of similarities within the descriptions. Some teachers (42) declared that, for different reasons, their lessons had to be asynchronous. Teachers (76) also indicated that they had the possibility to communicate synchronously with their students. However, a dominant trait in the teachers' descriptions was the tendency to mimic or reproduce the form of their face-to-face mathematics lessons but in an online setting (53 teachers declared this).

R97: They are lessons recorded and posted online, and I have consultation hours every day.

R64: I only send emails with activities and delivery deadlines.

R18: Two platforms are available for the lessons: Zoom to teach live every day of the week, both morning and evening. The Schoology platform is used to post recorded videos and activities to be solved online (questionnaires, crosswords, word searches). WhatsApp and email are used to send instructions and have contact with parents.

R168: They are lessons very similar to the face-to-face ones, with a traditional explanation supported by presentations, videos and the digital whiteboard. The students ask questions whenever they want, and they use the platform to reinforce knowledge and hand in their homework.

R25: I try to make them as similar as possible to the face-to-face lessons.

R180: I have two groups of students, undergraduate (Geometry) and graduate (Research Methodology and thesis supervision). In both cases we work through meetings via Zoom. At undergraduate level I present the subject. We use the sharing tool to look at the book in PDF, or the whiteboard, or GeoGebra. At first, I used an auxiliary camera to focus on a notebook in which (using it as a blackboard) I made operations or sketches, as required. But then I discovered a tool that has been very useful to me and allows me to write or draw over the file.

5.4 Implementation of Digital Tools

The digital tools that the mathematics teachers report having implemented can be divided into *mathematical digital tools*, that is, digital tools associated with the teaching of mathematics (n = 68) and *non-mathematical digital tools*, which are not necessarily associated with the teaching of mathematics but that allow for communication between teachers and students (n = 111). Example responses include:

R90: We use applications and applets such as GeoGebra, the games on the Spanish page of the Canary Islands, interaction on the Zoom whiteboard to build answers, a digital book, and YouTube to explain topics but with videos made by myself.

R114: The subject of numerical analysis has three tools: Visual Studio (C++), Mathematica and Simulink. The difference lies in the use of Blogger that is no longer used and YouTube videos. An example accompanied with exercises, and a problem to be solved as a team. Their homework is sent via WhatsApp Web. They [the students] do not like Blogger, they told me it is more complicated.

R9: I send the activity through Google Classroom and then I invite the students to share their doubts through Google Meet. But it is very difficult due to the limited time that the application gives you and not being able to use a blackboard.

R11: Brief explanations, video recordings on the YouTube platform, answering questions through Google Classroom and social networks.

5.5 Teachers' Emotions

When mathematics teachers were asked how they felt in relation to the transition from face-to-face to online mode of instruction, most of them (148) concurred in their expression of negative feelings such as stress, frustration, uncertainty, and worry.

R143: It was very abrupt, it is very stressful; there are no equal conditions for [internet] connection, neither between students, nor between teachers.

R32: Frustration, since I cannot reach even half of my students.

R42: Uncertainty, because we don't know how long we will be working like this, worried because not all of our students have access to digital tools.

R3: I am very concerned about those who do not have internet service, there are many and this greatly limits my interaction with them. The authority pretends that this does not matter.

R169: Only 10% of the students who enter into the virtual class participate. I sit talking alone. Human warmth is lacking. The order, discipline, organisation, participation, attention, punctuality and other factors that help the schooling of students, has been lost.

5.6 Teachers' Suggestions and Recommendations

Through the questionnaire, the mathematics teachers gave suggestions and recommendations for their colleagues who were going through the same transition to online teaching. These recommendations focus on time management (n = 65), the exploration of digital tools (n = 77), self-initiated training (n = 43), and emotional issues (n = 68).

R108: The most important thing is to put limits on the consulting hours for students, because once they have access to your mobile number or Facebook, they will send you messages at any time, any day and that is not very healthy. We must educate ourselves in organising our time and activities.

R155: Set defined hours to work. The virtuality has no end.

R6: Explore options, there are many resources available that we are not aware of and can contribute with something different to our lessons.

R2: We must take advantage of the possibilities that technology offers us. This is going to be a great opportunity to further explore tools that can improve the lessons even when we return to the [face-to-face] classroom environment.

R31: As teachers, we need to train ourselves in the use of digital tools.

R18: Learn, take courses, understand or try to understand how students think to determine what resources can facilitate their learning processes.

R11: Be patient, do not get discouraged if the percentage of active students decreases or does not increase.

R47: Be patient with ourselves, seek support and accept all possible help, be ready to look for information and be patient with parents as well.

R69: Do not be afraid and dare to address this new technological challenge.

6 Discussion

The aim of this study is to explore the way in which Latin American mathematics teachers deal with the abrupt implementation of digital technology in their teaching practices. Mathematics teachers were given a voice to express their feelings about this abrupt implementation and how they are responding to it in their practice.

The notion of teacher's voice is understood as the values, beliefs, emotions, practical experiences, and perspectives of teachers about their work. It also considers the degree to which those elements are considered, included, listened to, and acted upon when important decisions and changes are being made in the educational context where teachers develop their work. Thus, an open questionnaire was designed and implemented through which teachers could freely describe the material and technical difficulties experienced during the digital migration and suggestions they had to help other colleagues to navigate this digital transition. The open questionnaire also provided space for the mathematics teachers to express their emotional response to this abrupt implementation of technology in their teaching.

The analysis of the teachers' responses shows that they encounter obstacles to the implementation of digital technologies mainly related to poor or non access to the internet, and the lack of associated support and training from the educational authorities. The results of the study also indicate that the abrupt implementation of digital technology is time-consuming and can generate negative emotions for mathematics teachers. Finally, the teachers' responses suggest that during the first weeks of the abrupt implementation of digital technology, several of them focused on the problem of how to communicate and share information (files, videos) with their students, and not so much on the problem of how to represent and manipulate the mathematical content in the new instructional setting. This might be due to the abrupt conditions in which technology implementation took place, where the problem of establishing contact and fluid communication with students is a priority for the development of remote instruction and a prerequisite for online mathematics instruction.

Some of the results of this study coincide with the observations of Abboud-Blanchard (2014) and Thomas and Palmer (2014), who studied the phenomenon of the integration of digital tools into mathematics teaching. For example, we agree with Abboud-Blanchard's observation regarding the existence of commonalities in the way that teachers integrate technology into their classroom practices—regardless of whether the teachers come from different contexts. We have also identified

regularities in the implementation practices and in the obstacles reported by the different teachers who participated in the study. One of the regularities is the fact that the integration of digital technology can be time-consuming, particularly for those mathematics teachers without prior experience with the use of digital tools in their teaching. Time constraints and time-related limitations connected to the implementation of digital technology into mathematics teaching have been also identified in the studies of Abboud-Blanchard and Thomas and Palmer. The significant increase in the time required to prepare and teach an online mathematics lesson during the pandemic has also been reported by Italian university mathematics teachers (see Cassibba et al., 2021).

As in the work of Thomas and Palmer (2014), in this study the lack of training and the lack of access to digital resources were identified as obstacles to the implementation of digital technology in the teaching of mathematics. However, we argue that the impact that the lack of access to digital resources—particularly the internet—has on the development of mathematics instruction in the pandemic scenario is much greater than the impact that such lack of access to digital resources could have in the mathematics instruction of the pre-pandemic era. Here the data shows how the lack of access to a stable internet connection can have serious consequences for the relationship between the teachers and their students, such as the impoverishment of their interaction and feedback, and, in some cases, the inability to continue attending the mathematics lessons. The lack of access to a stable internet connection or to basic digital tools such as a computer or a tablet is probably not a common problem in well-developed countries. However, there are wide sectors in Latin America where these shortages are part of everyday life.

What we witnessed is a massive digital transition focused on overcoming the disruption in the teaching process caused by the pandemic. However, this digital transition exacerbates the already profound inequality between students from different regions of the world. The transition allows those students in better geographic and socioeconomic conditions to somehow continue with their mathematical education, but leaves behind thousands of students who cannot be part of this digital transition. This poses a huge problem of inequality in access to mathematical instruction that will profoundly influence the mathematical literacy of these future adults and the societies to which they belong.

The results of this study contribute to expand the perspectives developed by Abboud-Blanchard (2014), Thomas and Palmer (2014) and other scholars about the affective elements related to the integration of digital tools into mathematics teaching. Research on the adoption and integration of digital tools into mathematics teaching has usually focused on teachers' *beliefs* on the use of digital tools. Different mathematics teachers' belief systems have been identified, some more compatible than others with the integration of digital tools. An example of this is the work of Erens and Eichler (2015) who identified two general teachers' beliefs systems, which they called "the old school" and "technology supporter", and relate such beliefs systems to teachers' ways of integrating graphing and computer algebra systems in their calculus teaching. On the other hand, Abboud-Blanchard (2014) and Thomas and Palmer (2014) point to teachers' lack of confidence in using digital

technology as an obstacle to its implementation in the teaching of mathematics. Such lack of confidence could be interpreted as a self-efficacy belief (Bandura, 1993), i.e., teachers' beliefs in their personal efficacy to put digital technologies to good use in the mathematics classroom. However, the exploratory study reported in this chapter brings to the fore the *emotions* experienced by mathematics teachers during the abrupt process of implementing digital tools into their teaching. Emotions are a more intense and less stable affective element than beliefs, however, beliefs and attitudes are thought to arise from emotions (McLeod, 1992; Schukajlow et al., 2017). Most of the emotions expressed by the teachers who participated in this study were characterised by a negative valence (stress, frustration, worry) and the object of these emotions was the abrupt process of implementation of digital tools into their teaching. Since emotions are the basis on which beliefs and attitudes are consolidated, we think it is necessary to pay more attention to these affective elements that are triggered by the process of implementing digital tools. It is important that mathematics teachers are heard with respect to what they feel and do during processes of digital transformation.

As noted earlier, this study did not directly observe the implementation of digital tools into the teachers' practices during the COVID-19 pandemic. This is an aspect that needs to be addressed by future studies to corroborate and complement the findings reported in this exploratory work. We believe that the study of mathematics teachers' practices in the post-pandemic digital era is one of the topics that will require the attention of researchers in the years to come.

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Appendix: Questionnaire Given to the Mathematics Teachers Who Participated in the Study

1. The educational system(s) where you work, is it public or private?
2. Indicate the educational levels in which you work
3. Do you have internet access at home?
4. Before the health emergency and the suspension of face-to-face instruction, was it usual for you to use digital tools in your courses? If your answer is yes, indicate which ones you used.
5. Were you instructed to change to the online teaching format? If your answer is yes, from what authority did you receive the instruction?
6. Upon receiving the instruction, was any digital tool provided to you to develop your work? Did you receive support on this respect?
7. How did you adapt the mathematical content and its approach to the virtual format? How long did this take?
8. Describe your mathematics lessons in the virtual environment.

9. Specify the digital tools that you currently use with your students to develop your courses.
10. How do you feel about the transition from face-to-face to online mode of instruction?
11. What suggestions or recommendations would you make to other colleagues who are undergoing the same digital transition?

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