Learning from the pandemic: Capitalising on opportunities and overcoming challenges for mathematics teaching and learning practices with and through technology

Conference or Workshop Item

Learning from the pandemic: Capitalising on opportunities and overcoming challenges for mathematics teaching and learning practices with and through technology

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This working group (WG), which met for the second time in June 2021, was created to discuss the theoretical and methodological challenges faced by the mathematics education field when the prevailing boundaries of the classroom shifted as a result of the COVID-19 pandemic. Following a brief introduction to the aims for the WG, we offer three further case studies of teachers' practices and an emerging synthesis of the cases according to three pedagogic activities that are proving to be particularly challenging.

Keywords: online mathematics teaching and learning; home schooling; technology, online professional development; digital resource.

Introduction

This WG, which first met at the Spring 2021 BSRLM Conference aims to build understanding of how practitioners have responded (and are continuing to respond) to the challenges of teaching mathematics online; and the evolution of the related practices. Starting with the assumption that technology resources *are* being used, the WG aims to explore the nature of these digital tools and their affordances, that is, what they offer to mathematical teaching and learning. Each WG session has included three presentations from the BSRLM community that are used to stimulate online synchronous discussion, mediated by a Miro board[1].

During the WG sessions, participants are encouraged initially to structure their thinking (from practical, theoretical and methodological perspectives) around the following three pedagogical themes: introducing and developing understanding of new mathematical topics; managing interaction and communication in mathematics; assessing mathematics, both formatively and summatively. Alongside, we capture and report other emergent themes that seem important to us.

The case studies

During the session, three case studies were presented, which are summarised below. This brings the total number explored by the WG so far to six.

Case study 4: Learning opportunities from teaching A-level mathematics remotely. A presentation by Christopher Shore

This case study presents an intervention with a group of my year 13 students (17-18 years) taking A Level Mathematics at a large English comprehensive school. These

[1] The Miro board can be viewed at: https://miro.com/app/board/o9J_l7fxTP0=/

learners had experienced significant disruption to their post-16 education across both years of their studies due to the COVID19 pandemic to include long periods of school closures combined with periods of isolation when their 'bubbles' were sent home. I designed the following remote teaching intervention in March 2021, during the second period of school closures.

The intervention was designed to problematise aspects of pedagogy, technology and curriculum. Remote teaching was developed at pace, and it proved fairly easy to replicate some elements of typical classroom practice, such as teacher exposition and students' practice of text-book exercises, with teacher support when needed. I questioned what different pedagogical approaches might be facilitated by the use of technology in this remote learning environment and I was particularly interested to explore whether online tools might enable a greater 'discovery' approach to learning during asynchronous learning episodes. This led me to consider what online tools were available for the learners; and to what extent the affordances of those technologies might translate to learning opportunities. Finally, I considered the syllabus I was required to teach and whether there were areas of the mathematics curriculum that lent themselves to these different pedagogical approaches presented during remote teaching. Answers to these questions are interconnected. For example, choosing a particular curriculum area might lend itself to a particular digital learning environment, and choosing a particular learning environment might lead to choosing a certain pedagogical approach. This led me to consider the Technology, Pedagogy and Content Knowledge (TPACK) theoretical framework (Mishra and Koehler, 2006) to frame my study as it accounts for the different domains of teacher knowledge that are reflected in my questions.

One of the main affordances of using mathematical digital technology is the ease with which mathematical constraints and variables can be manipulated. This is especially valuable when discerning invariance against a backdrop of change (Leung, 2008) which can be brought about, for example, by dragging in a dynamic geometry environment. I chose the curriculum area of locating roots of functions using the Newton Raphson method because this had obvious points of invariance (the root). I also wanted to explore whether using digital technology could support a pedagogical approach that led to the learners 'discovering' the Newton Raphson method for themselves, rather than relying on me to tell them of it. To support these choices, I chose open access classroom activities at teacher.desmos.com as the digital technology to be used during asynchronous learning. I designed activities for the learners to work through that involved different modes of learning and included static and dynamic images, closed and open-ended questions, and freeform drawing inputs.

Whilst the analysis of the data from the intervention is still ongoing, an emerging finding is the frustration learners reported when engaging with asynchronous activities; they still value direct input from a teacher. For example, after reflecting on the intervention, Student S said, "using technology is more engaging but at the same time you do need some follow up discussion about what you just learned to make sure that you are doing it correctly." I believe this shows the learners' desire to get the technique right so that it could be correctly applied in any future assessment. This could be mitigated with more feedback to the learner, perhaps through the digital learning environment.

Case study 5: A Level students' challenges of learning mathematics remotely through technology during the January-April 2021 lockdown – A presentation by Ebert Gono

This case study explores how English A-level mathematics students at the post-16 centre where I work experienced remote learning during the COVID 19 lockdown from Jan - Apr 2021 guided by the following three aspects: (a) the quality of technology and internet access; (b) students' home environments; (c) the impact of remote learning on students' mental wellbeing. It aims to derive meaning from the students' perspectives, therefore a qualitative approach was appropriate. Sixty-three of the one hundred and seven A-level students provided a paragraph that described their experiences of remote learning, which were analysed to draw out findings that would inform the development of the Centre's practices. These are summarised below.

Quality of Technology and Internet Access. The findings revealed a stark divide in individual students' access to both a technology device and a reliable internet connection. Whilst the majority reported positive experiences of remote learning, about 13% of the students (from areas of the city where deprivation is very high) expressed problems due to poor internet broadband strength. This made remote learning experience very stressful for them, their learning was interrupted, and some students requested to retake the year. For example, one student indicated that he relied on pay-as-you go service and found it expensive to access video conferencing. In addition, communicating responses during live sessions was difficult for all students and only two students were able to access and use microphones. Typing mathematical symbols on the keyboard was not easy for students either, hence communication was mostly one way (from the teacher to the students).

Students' home learning environments: Thomson (2020) argues that students from disadvantaged backgrounds are likely to be more at risk of falling behind during remote learning, due to, for example noise distractions from siblings, TV or music. The present study confirms these findings with students reporting that parents and siblings were also working or studying from home. This put extra strain on students and families to negotiate access to the limited devices available in the home. Cultural factors also impacted and one student highlighted how she was not allowed unsupervised access to technology, due to her parent's beliefs and values, which impacted negatively on her particular access to remote learning.

Impact of remote learning on students' mental wellbeing: The analysis of students' reflections revealed that anxiety, lack of interaction with peers and frustration due to slow internet all affected their mental wellbeing. These reflections concur with studies on "passive following" within social media use that also conclude negative impacts on mental wellbeing (See for example, Krasnova et al., 2015). One student boldly stated that the whole remote learning experience was very depressive, and he suffered from a lot of anxiety as a result. With communication limited mostly to typing on the keyboard, not an easy task when typing mathematics symbols, students felt isolated. This was hampered by their lack of access to, or use of, microphones.

Students' positive experiences of remote learning: The findings were not all negative. In this period, college attendance figures increased, despite the difficulties some students faced with internet connections. However, this alone cannot be used as a measure of good remote learning experiences. One stated, "I found online lessons better as I was able to do my work in the comfort of my own home. I've managed to

catch up a lot in lockdown" and another commented on the high quality of the online lessons. Also, all mathematics lessons were recorded, which gave students an opportunity to play the lesson back. As a college, it was possible for most students to remain engaged during the lockdown.

Analysis of the students' responses showed more positive experiences than negative. However, this small study highlights the inequitable access to education and a loss of learning opportunities for students from socially deprived backgrounds, which has impacted negatively on their progression. It also highlights the importance of quality peer-to-peer and student-to-teacher interactions within the learning of mathematics. This implies that, in the future, remote learning with technology, should be blended with face-to-face sessions, possibly leading to an increase in the integration of technology. Such a direction highlights the need for teachers and lecturers to carefully select technology appropriate for teaching mathematics, taking the complexity of communicating mathematical symbols using specialised software into consideration. To conclude, it seems that training for teachers and students on the use of selected technologies will need to be prioritised.

Case study 6: Evolving pedagogy during the pandemic - A presentation led by Andrew Neate

In this case study, interviews were conducted with six Welsh mathematics educators: two secondary school teachers and two university lecturers who had no experience of online teaching before the pandemic, and two tutors who were already involved in blended online teaching before the pandemic. The interviews focused on their experience of online teaching during the pandemic as compared to their usual practices.

The research is informed by the Community of Inquiry framework (Garrison, Anderson and Archer, 2000; Garrison and Arbough, 2007) that considers learning as a personal experience of reflection and discourse supported socially in a community orchestrated by the teachers. The framework is composed of three factors: *Social Presence* (i.e., "the ability of learners to project themselves socially and emotionally, thereby being perceived as real people" p. 159), *Cognitive Presence* (i.e., "the extent to which learners are able to construct and confirm meaning through sustained reflection and discourse" p. 161) and *Teaching Presence* (i.e., "the design, facilitation, and direction of cognitive and social processes for the purpose of realizing personally meaningful and educationally worthwhile learning outcomes" p. 163) (Garrison and Arbaugh, 2007).

For those who had never taught online before, the initial challenge was to create a teaching presence in the virtual environment. This included generic aspects such as how to use a virtual classroom ("it was a big shock in that we'd never done Teams before") but also specific mathematical aspects including the challenge of writing and communicating mathematics on a screen.

For the schoolteachers, the loss of the classroom environment where "everyone was there to help each other" was a key challenge in terms of providing support and judging students' cognitive engagement in lessons. There were challenges in creating both social and cognitive presences within safeguarding policies that, for example, stipulated that students should not use cameras during online classes. This lack of two-way communication hampered the teachers' abilities to assess the success of lessons, so grading and returning student work became crucial for teachers to understand if the students were learning. University lecturers would normally have a

limited understanding of students' cognitive presence relying on audience cues: "when the students were on the edge of their seats, they were engaged". The loss of these cues was felt, with one commenting "I struggled because of the lack of the interaction with the students…. it's hard to know whether they are learning properly." The lecturers had considerable freedom to experiment with a diverse range of approaches ("I went a little bit maverick"), for example taking a flipped approach to classes. They also identified the importance of using technologies chosen by the students to communicate outside of lectures. For example, Discord[2] was used because "it's something run by them, for them, and I'm there to help… It's a community collaborative effort."

The tutors who were already involved in blended learning before the pandemic experienced the least disruption to their teaching but were still concerned about tools and approaches to write mathematics on screen. As they were unable to carry on with a traditional blended approach (online lesson combined with face-to-face support), they introduced the flipped classroom approach to allow for more problem solving and collaborative work in class to facilitate deeper learning and cognitive presence.

Across all three groups, educators expressed a desire for students to have better access to technology (such as tablets) that would allow them to write and share mathematics more readily as a way to enhance all three presences. Flipped learning was the one approach that lecturers and tutors might elaborate on when returning to 'normal' teaching. School teachers however, emphasised the need for more time to reflect, but did highlight that operating in an online environment had made them aware of the wide choice of online resources available (with preference given to whole packages which included assessment tools) and professional learning opportunities to support the use of new technologies.

Emerging evidence from the first six case studies.

During the online WG sessions, the participants have been synthesising case study data in alignment with the three pedagogic themes (see Table 1).

	Introducing and developing understanding of new maths topics	Managing interaction and communication in maths	Assessing maths, both formatively and summatively	Emerging themes
Case study 1[3]	Synchronous practical demonstration of geometric proofs using a visualiser.	Synchronous modelling of students' responses using card shapes.	Enabled by the shared use of the visualiser.	How to 'model the mathematics' to encourage 'student engagement' and promote 'active learning'.
Case study 2[3]	Problems set in advance & synchronous session to share solutions.	Synchronous annotation of shared images, online graphing software & revealing of pre-prepared solutions.		How to create opportunities for students to experience the integral nature of reading/ writing in maths.

[2] Discord (https://discord.com/) is a voice, video and text-based communications platform that is popular with students.

[3] The first three case studies are detailed in Crisan, C., Bretscher, N., Clark-Wilson, A. and Geraniou, E. (2021) Proceedings of the British Society for Research into Learning Mathematics, 41 (1). Online at https://bsrlm.org.uk/wp-content/uploads/2021/05/BSRLM-CP-41-1-06.pdf

Case study 3[3]	Modelling the use of dynamic maths software, contrasting by-hand methods	Interactive whiteboard, text chat, emoticons, presenter thumbnail	Formative assessment overt but limited e.g. using text chat, snapshot polls	Revealing constraints when modelling mathematics pedagogy.
Case study 4	Static/dynamic images, closed/open-ended questions and freeform drawing.	Asynchronous, which forced the teacher's attention to detail when planning tasks.	Full visibility of students' activity, followed up via oral discussions with students.	The need to provide reassurance to students that their methods (and learning) is valid.
Case study 5	Modelling of written maths on a physical whiteboard streamed via webcam.	Online "chat" of mostly words and numbers - little use of maths symbols/syntax.	Little or no opportunity.	Exposing the digital divide. Increasing student isolation.
Case study 6	Flipped approach - Video lectures followed by asynchronous online chat.	Adopted student choice of technology (Discord).	Feedback provided within the technology.	Establishing students' social presence was the priority.

Table 1 A first draft synthesis of the first six case studies classified by pedagogic themes

Over one year on from the first Covid-19 lockdown, assessing students' mathematical outcomes is clearly still a challenge, as captured by one WG participant's comment, "Is it too soon to be asking questions about learning maths? We're still grappling with the technology!" This challenge will be the particular focus for the next meeting of the WG.

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