

Riding the Wave of COVID-19: The afterMATH

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In this paper, we present research on New Zealand secondary teachers' perspectives of teaching and learning mathematics during the COVID-19 pandemic of 2020–2023. We use narrative analyses of interviews to explore the perspectives of eight participant teachers. COVID-19, and its resulting restrictions, were found to impact student-teacher relationships, teachers' ability to provide mathematical explanations and support students' learning, and students' engagement and participation.

In this paper, we focus our attention on eight New Zealand secondary mathematics teachers' perspectives of the impact the COVID-19 pandemic, and the resulting restrictions, had on teaching and learning mathematics. Learning mathematics is a social practice and is unique in terms of its nature and importance, as well as students' relationships with the subject (Ingram, 2011). We describe how the unique features of school mathematics led to specific and unique challenges for mathematics teaching and learning during that period. Therefore, we shed light on why these features of mathematics are essential characteristics, and how teachers can best address them in the context of ongoing secondary mathematics teaching and learning.

With the COVID-19 pandemic raging in other parts of the world, and with the government pursuing an elimination strategy, New Zealand closed its borders in March 2020 and, soon after, a strict lockdown was announced (Ministry of Health, 2021). This noon announcement closed schools immediately and teachers and students were sent home to navigate a long, initial, 8-week lockdown, as well as subsequent lockdowns. For the next two years, despite the borders remaining closed until 2022, schools emerging from lockdown needed to operate through restrictions and increasing sickness in their school communities. During that period in New Zealand, an infected person had to self-isolate for 14 days with their household contacts. If someone else in the household contracted the virus, all had to start on day one again, meaning that teachers and students could be absent for weeks or even months (Ministry of Health, 2021). Waves of COVID-19, and resulting impacts within schools, continue at the time of writing.

It was within this COVID-19 pandemic context that our main research project was situated. In mid-2023, we constructed a narrative of teaching and learning during the COVID-19 pandemic from the perspectives of mathematics and drama teachers in New Zealand. We were interested in their perspectives on the ongoing educational cost of the pandemic, and the differences and similarities between drama and mathematics teaching and learning. All teachers described their work, their challenges, and accomplishments. They were flexible and creative in their practices and focused on their students' well-being and learning. All teachers were impacted professionally and personally by the pandemic. Here, we focus on the mathematics teachers' perspectives. We first explore the recent educational research related to COVID-19. We then outline the unique features of mathematics teaching and learning and what they mean for mathematics teaching practice. Then, we explain and justify our narrative inquiry research design. Our findings are discussed regarding the relevant literature, and conclusions reached.

The Impact of COVID-19 on Teaching and Learning

Despite the COVID-19 pandemic being so recent, there is a body of research that explored this period, emerging from around May 2020 (e.g., Capurso, 2020). These accounts offer a window into the beliefs, values, and attitudes of researchers and participants while situated within the pandemic context and provide insights into how school communities evolved.

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When countries went into lockdown and schools needed to move to online teaching, a range of barriers to teaching and learning emerged. There was the visceral uncertainty and distress caused by the pandemic and people's individual lockdown situations. The uncertainties of the pandemic and the fear of contracting the virus took a toll on the well-being of teachers and students and added to an already challenging school context (d'Agnese, 2023). During lockdown many schools prioritised students' mental health, and when schools re-opened, this emotional support needed to be balanced with students' academic recovery. This added to teachers' responsibilities and, in turn, further impacted teachers' own well-being (Capurso et al., 2020). Furthermore, the initial lockdowns and the subsequent years of sickness and restrictions are considered to have had a profound impact on students' educational outcomes as well as teachers' professional lives (Chaaban et al., 2021; McCluskey et al., 2021). There has been a particularly negative educational impact on those students who were already socially isolated, traumatised, or educationally disadvantaged in some way (Mutch, 2021).

Most schools required their teachers to move online for their teaching. At least initially, many teachers did not have the technological knowledge and skills necessary for working online, and there was unequal access to digital devices and good quality internet connections. Furthermore, there was relatively low student engagement and participation, and a range of other issues such as students' lack of camera use (Joseph & Trinick, 2021). These barriers made connections difficult between teachers and students and impacted learning (Akojie et al., 2022). For example, Walters et al. (2022), surveying 462 Welsh secondary school students found that student engagement, concentration, and ability to learn were significantly lower.

The range of barriers to teaching and learning related to COVID-19 described in the general education literature was also evident in research that specifically explored mathematics. For example, Noviani (2021) described internet access, time management and eyestrain as general barriers to learning. However, they also noted that students' reluctance to ask for help was a particular barrier to learning in mathematics during the COVID-19 period. Similarly, in the research of Mukaka et al., (2023), as well as confirming the pragmatic barriers to teaching during COVID-19, they concluded that mathematics is best taught when there is face-to-face guidance from the teacher. These factors are both related to students' need for individual interaction and support from the teacher and are particularly relevant to existing research that describe mathematics as a social practice with a unique nature, which will be explored now.

Learning Mathematics

Learning school mathematics is a social practice that is situated in the mathematics classroom (Op 't Eynde et al., 2006). Students need opportunities to discuss mathematics, and seek help from others (Ingram, 2011). An effective learning environment and positive relationships within the classroom community are therefore important as well as the co-construction of classroom social norms and socio-mathematical norms specific to the mathematical activity. Some examples of these norms are what constitutes a mathematical explanation, how a problem should be solved, and how students and teachers should interact during the classroom activity (Yackel & Cobb, 1996). Given the barriers of the online teaching environment necessitated by the COVID-19 pandemic, it would be a difficult context to enable discussion of students' emerging mathematical ideas, and it would be difficult for students to seek and get help, as found in Noviani's (2021) and Mukaka et al.'s (2023) research.

Furthermore, mathematics is a unique school subject. According to longitudinal research of secondary students' relationships with mathematics (Ingram, 2011), mathematics is more 'thinky', more important, more difficult, and more disliked than other subjects. Furthermore, many students described their mathematical knowledge as 'a tower'. In other words, they saw mathematics knowledge as cumulative and their learning of mathematics as a process of construction building on their existing knowledge, skills and understandings (Hantano, 2013).

Effective mathematics teaching therefore includes the provision of strong explanations and a range of strategies to support students' learning (Anthony & Walshaw, 2009). Furthermore, because of the cumulative nature of mathematics, it is particularly difficult to catch up on when a student is disengaged or is absent and they have a gap in their knowledge (Ingram, 2011). Lastly, students' engagement in mathematics—their doing of it—is synonymous to learning (Op 't Eynde, 2006). Given these perceptions and understandings, students learning mathematics may not have been resilient to the barriers they faced during the pandemic.

In this research, we were therefore interested in exploring mathematics teachers' perceptions of teaching and learning during the pandemic. We were attentive to the unique nature of teaching mathematics, and the necessity to support students' learning and engagement in the subject through participation and discussion, which were impacted during the COVID-19 pandemic. Our research questions were:

- What were the mathematics teachers' recollections of teaching during the COVID-19 pandemic?
- How did mathematics teachers support students' learning during the COVID-19 pandemic?
- How were students' engagement and participation in mathematics impacted by the COVID-19 pandemic, from the mathematics teachers' perspectives?

Research Design

To capture mathematics teachers' experiences and perspectives of teaching during the pandemic, we were informed by a narrative inquiry approach (Clandinin & Caine, 2013). Narrative inquiry draws from oral history, drama, psychology, and folklore traditions. Individuals construct their reality through the telling of stories (Chaaban et al., 2021). We lived alongside our participants as they shared their stories of the COVID-19 period.

Within the main research project, there were 14 volunteer participants recruited by advertising through subject associations. Eight of these were mathematics teachers, who are the focus of this paper. The mathematics teachers' ages ranged between 33 and 58 and they came from a range of rural and urban schools throughout New Zealand and had a range of years of teaching experience from 8 to 35 years. Pseudonyms have been used to protect their identity.

The participants shared their stories in interviews using Zoom either as an individual or in a pair with a drama teacher. The interviews were conversations with a purpose, semi-structured and informed by the research questions. The mathematics teachers were asked about how they prepared to teach during the enforced lockdown due to COVID-19, and their perspectives on how the pandemic impacted their mathematics teaching, and their students' learning.

The analysis occurred in four stages. The interviews were transcribed using a transcription tool, Otter, and then listened to as the transcripts were checked for accuracy. These transcripts were uploaded into a qualitative software package, NVivo, and the data set was coded into categories. Codes were changed, consolidated, and reduced as understanding grew of the data. Through constant comparison, the analysis moved to and fro between the general and the specific. Once main categories were formed, these categories were developed further and gradually 'teacher-student relationships', 'providing explanations', 'supporting students' and 'engagement and participation' emerged. Informed by narrative inquiry methodology (Clandinin & Caine, 2013), the data were ordered into a chronological narrative, structured by the time periods, and informed by the categories. The findings begin with this narrative. This narrative then provides the context for the specific focus on how teachers supported their students' learning and their perspectives on students' engagement and participation.

Findings

When lockdown was announced and mathematics teachers were sent home from school, they needed to scramble to get ready for online learning. Fern “broke the rules, going back into a building to pick up a bunch of textbooks that [they] could start scanning”. Alex was allowed back into his school and picked up workbooks, textbooks, paper, and a small easel whiteboard. Sam also “stole a whiteboard at the last minute”. Frankie had no idea what to take home and ended up filling “half her car”. Sam had no power cord so her colleague “bashed in and picked it up”. These stories account for the stress the teachers were under as the country went into full lockdown. This stress was particularly apparent for teachers who had little or no experience with online learning. For example, Reese was “panicking—I didn’t know this stuff”.

The teachers began to adapt their teaching and programmes for the lockdown. Their students did not have equal access to devices or consistent internet connection and, therefore, materials were delivered. For the students able to be online, the teachers used a variety of online tools, including Zoom, software from the Google suite (e.g., Meet, Classroom) or the Microsoft suite (e.g., OneNote, TEAMS). Fern switched her junior mathematics classes to measurement so students could do measuring tasks around the home. For her senior programme, Frankie removed several assessments, and Riley changed her topic to algebra because she perceived it would be easier to teach, although she “watered down what [she] would normally do”. The data set suggests, that due to the cumulative nature of mathematics, the students were not receiving the same mathematical content that they would normally get during this period, which would impact their mathematical knowledge and preparedness for later learning.

Returning to face-to-face teaching after the lockdown was stressful for students and teachers due to a combination of unprecedented complexities, in particular, the COVID-19 restrictions such as physical distancing and mask-wearing. Furthermore, as the sickness spread throughout New Zealand, and students needed to stay home due to restrictions, absences were prolific. “My department got sick, I got sick, the kids were always sick” (Reese). The teachers described being overwhelmed by the “messy” situation (Sam). For example, Fern described the teachers needing to provide “in-class tuition for everyone who was there ... also the online stuff for all the kids who weren’t in the room, and ... the staff who weren’t there”. Fern’s stress as she described having to cope with multiple elements during this period was still evident three years later when interviewed for this project. Like many teachers during the COVID-19 pandemic, Fern had a very young child at the time and was herself concerned about bringing the sickness home, attested to her professionalism and hard work during this period, especially as it came immediately after needing to teach from home during the stressful lockdown period.

This brief narrative of the teachers’ experience during the pandemic has similarities to the literature related to teaching online. The mathematics teachers found creative solutions to keep students connected despite the distance. They utilised resources in the students’ homes (Yates et al., 2021), they delivered materials directly to students to help ameliorate unequal access to online learning (as in Akojie et al.’s research, 2022), and they used digital tools seen in other research (e.g., Joseph & Trinick, 2021). The literature is around online teaching during the lockdown period—this research further describes the teachers’ preparation for lockdown and the sheer chaos of coming back to school as sickness, and absences, grew.

The teachers’ descriptions of teaching and learning mathematics during the pandemic provide context for the findings related to specific aspects of mathematics teaching. These include teachers’ relationships with students, providing mathematical explanations, supporting students’ learning, and supporting students’ engagement and participation in mathematics.

Teachers' Relationships With Students

Student-teacher relationships were under pressure during the COVID-19 pandemic. Already dealing with the difficult situation of the impending illness, relationships were further compromised due to the pressure of online learning during an emergency lockdown, and the unequal participation due to devices and internet connection. Furthermore, many schools did not require students to have their cameras on because of concerns about student privacy and the quality of the internet connection. When the students came back to school, the restrictions hindered the ability of teachers and students to rebuild positive face-to-face relationships. It was especially “hard to get to know the students” because of the physical distancing and mask-wearing and because the students had begun the year only a few weeks before lockdown.

The teachers in the study knew relationships were important for their students' well-being and mathematics learning. Frankie explained, that if a mathematics teacher has a good relationship with their students, they are “more open to learning harder concepts” and do not have “walls built up as much ... and are more willing to be challenged and more willing to try new things because they trust that you can get them through it”. They therefore worked hard to continue to build their relationships with the students during the pandemic. For example, during lockdown, Sam introduced a “weird, funny, Friday”. Frankie put “on a great show for the kids ... because we have to teach maths to kids who don't like maths”. Alex used “little things to catch their attention such as figurines, stuffed toys—a comic relief sort of thing”. Reese encouraged her students to arrive early for their online classes so they could chat socially on Zoom. Fern explained one of the most useful adaptations she made was non-content related sessions such as “a lot of silly, let's paint on our selfies kind of stuff that kept them connected”.

A clear theme was that the participants in the study underlined the need for collaboration and interaction among mathematics teachers and students, to foster a more relational and engaging online learning environment (d'Agnese, 2023; Joseph & Trinick, 2021). The COVID-19 pandemic, both during the online period and after schools resumed, made relationship-building complex and difficult. Consequently, student's mathematical learning and teacher-student relationships were compromised. The teachers' perspectives reinforced that having positive student-teacher relationships make a difference to the learning environment, to the students' well-being and to the quality of the students' mathematical learning (Yackel & Cobb, 1986).

Providing Mathematical Explanations

The mathematics teachers sought ways to provide mathematical explanations for their students. All attempted to make short content videos by recording their working in real-time as they talked. Fern described the awkward first days of attempting to film herself writing on a whiteboard with her phone using two cameras, so her students were “able to see me write and talk at the same time” (Fern). Other teachers used a camera attached to a computer, a camera focussed on the now precious ‘stolen’ whiteboards or asked their partners to hover their phones over a piece of paper as they wrote. Sam found a Screen Casting app on a tablet useful. The teachers either shared these videos in real-time and/or uploaded the recordings for the students. The whiteboards were essential for these teachers, and they all attested to their creativity in trying to capture their explanations. Except for Sam, they did not have access to a screen-casting app, or perhaps did not know about these apps, which are useful for recording lessons, students' problem solving and mathematical working (Ingram, et al., 2018).

Furthermore, the analysis illustrates teachers and students co-constructed new norms for working in the online environment. In Alex's class they developed class norms for working together online. “[The students] developed their own, essentially sign language for answering questions, because we were doing algebra. They came up with things for factorise, bracket, x, and square. It was a bit easier ... because ... you can't have everyone talk at the same time on

video”. These findings highlight how challenging it was to teach mathematics effectively if the students’ cameras were turned off, and attest to the importance of co-constructing a learning environment and sociomathematical norms in the classroom (Yackel & Cobb, 1986).

Supporting Students’ Mathematical Learning

New ways needed to be developed to ensure students could get feedback and support from their teachers and peers about their mathematical learning. Frankie’s students were asked to submit or share work by taking screenshots and posting photos or engaging in online programmes. Fern asked the students to use their cameras to share their working by holding it up to the camera to get immediate help. She noted the students who needed the most help often were the ones most reluctant to hold their work up and was frustrated by this. “In a normal class I’d make sure I was side-by-side with these students to ensure they were getting the support they needed”. This is an interesting comment. Often, we talk about face-to-face learning, but in Fern’s case she needed more than that—she needed to be side-by-side.

Not all students were reluctant to ask for support. Jo’s school, which only offered asynchronous teaching, encouraged students to be in frequent contact with their teacher. This was difficult because the students had an expectation “they could contact [her] any hour of the day and night, and [the teacher] should respond immediately” (Jo). Sam described her senior students as “needy” because they seemed to have learned helplessness in their constant questions and their need for support to work through mathematics.

Even when school-based mathematics classes resumed after lockdown, the requirement for students and teachers to wear masks, and the need to be operating at a distance from each other, impacted their face-to-face mathematical learning. Fern could still not get side-by-side students to support their learning. Sam explained that the mask wearing directly affected the students’ learning of the mathematical content. She noticed some students:

Struggled to hear ... and understand what’s going on. I use lip reading ... when I teach. It is possible that the students use lip reading without realising it, so it would be much harder for them to comprehend and connect to take in what we are doing while wearing a mask. (Fern)

Indeed, Sam was surprised at how much she needed to read students’ facial expressions as she was teaching to support her formative assessment and decision-making about her teaching. “You can’t read their expressions. I didn’t realise I get so much from looking at a student. It’s really hard ... without seeing them”. Fern commented that “trying to read a confused face on a kid wearing a mask” was problematic. Reese agreed. “You realise how much you rely on reading the room because they’re all behind a mask, and you can only see their eyes ... yeah, that was hard”. Much of the literature related to teaching and learning during the COVID-19 pandemic was related to online learning during lockdown.

There is little research available about mask-wearing when teaching face-to-face. Mathematics teachers, are constantly needing to make decisions as they teach, based on their minute-to-minute formative assessment, the feedback they get from students, the questions they are asking and the difficulties they are experiencing. It is clear from our data analysis that the COVID-19 period made some commonly relied-on teaching techniques difficult. The complexities of learning mathematics while wearing masks may also have reinforced some students’ perceptions of mathematics as a difficult and disliked subject (Ingram, 2011). The need for the mathematics teachers to be physically side-by-side their students was apparent.

Students’ Engagement and Participation in Mathematical Learning

According to the participants in our study, students’ engagement in mathematical learning and absences from class were a major problem throughout the years of the pandemic. Some students were able to get into a routine of online learning during lockdown, making the space and time work for them. Also, despite the restrictions, some students were able to connect with

the school environment when schools re-opened. All teachers described a large proportion of their students, however, who did not engage fully. They did not engage in discussion; they did not ask for help, and they did not consistently submit work. Some were not able to participate at all due to power or internet connections. Some parents did not want their children to be online for extended periods. Sam's school was in a rural area and many of her students were expected to help on the farm. Alex's school did not expect teachers to hold absent students to account due to concerns about their well-being. When schools resumed, absenteeism became even more rife as communities got sick and people were expected to stay home by law.

The teachers believed the students' well-being contributed to students' absences and engagement, as they "watched students' mental health decline" (Fern). This had an impact on their learning and their ways of working. Jo thought that "kids seem to have lost the importance of education". They were "very slow ... it's a real struggle to get them through what we need to cover ... and to get them to have a sense of urgency about completing tasks" In Alex's view, his students struggled with self-motivation and retaining mathematical content knowledge.

Many students were behind in their schoolwork, which further impacted their anxiety levels. Missing content in mathematics is a "much bigger deal" (Fern) because of the nature of the subject. Alex found that, after lockdown, some students, who "had not engaged at all, ... were so far behind ... [and] they didn't want to admit they were behind". Alex explained it was additionally hard to maintain relationships with students who were so far behind and feeling anxious about it. This was further exacerbated because teachers were asked to be more lenient to students about absences and assignment deadlines and therefore the return to any expectations that they would complete work by deadline dates would have been difficult. This is consistent with literature that describes the issues around leniency for work output expectations during the COVID-19 pandemic (e.g., Joseph & Trinick, 2021; Yates et al., 2021).

Conclusion

Teachers needed to deliver mathematics as effectively as possible throughout the COVID-19 pandemic of 2020–2023, throughout the initial lockdown, subsequent lockdowns when schools resumed, and throughout the ensuing sickness, restrictions such as enforced absences, masks, social distancing, and sanitation requirements. The teachers in our research described the ways they were limited in their ability to deliver mathematics effectively during that period in terms of their relationships with their students, their ability to provide explanations, and their support of the students' learning. They also described how their students' engagement and participation in mathematics were impacted.

These are the perspectives of only eight mathematics teachers in New Zealand—a limited number necessarily pragmatic because of the pandemic. However, richness is provided through descriptions of the barriers to teaching mathematics at the beginning of lockdown, in the stressful days before, and coming back to school. The challenges caused by the pandemic serve to accent the importance of the essential elements of mathematics teaching—having strong student-teacher relationships, co-constructing a learning environment, having strong student engagement, and teachers being side-by-side with students to support their learning.

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