COVID-19 AND THE QUALITY OF MATHEMATICS EDUCATION TEACHING AND LEARNING IN A FIRST-YEAR COURSE

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ABSTRACT

This article is vested on the need for higher education educators to be reflective on their practices in order to configure effective ways to interact with the students and knowledge for specific courses. It is uncontested that education systems globally are under constant pressure to respond to the changing needs of societies. The outbreak of COVID-19 has reminded us that the complexity of education needs responsive practices to facilitate effective teaching and learning across all levels of schooling globally. All over the world, the normative ways of teaching and learning evolved drastically in the first quarter of the 2020 academic year when teachers and students found online offerings to be the dominant option available as a sequel to the pandemic conditions. In South Africa specifically, students and teachers were thrust into virtual teaching and learning situations with the majority of them having no preparation for this shift. This article presents an auto-ethnographical account of the knowledge gaps in the teaching and learning of mathematics education in a first-year education course in an online space. We used auto-ethnography to discuss our experiences of teaching limits and continuity. We argue that teaching the topic on an online platform constrain student teachers' procedural thinking, conceptual development, and demonstration of their thought processes during mathematics learning and assessment. We also discuss our experiences of developing assessment tasks for the topic and how students identified cheating mechanisms to answer questions in assessments.

Keywords: COVID-19, education, mathematics education, online learning, quality, challenges

INTRODUCTION AND BACKGROUND

The respiratory failure and unwavering deaths caused by COVID-19 continue to cause sparked anxiety worldwide. In South Africa, the Minister of Health Dr. Zweli Mkhize reported the first case of the pandemic on 5 March 2020, when a male citizen in KwaZulu-Natal tested positive

upon his return from Italy. It was in this context that the government configured strategies to fight against the virus on March 2020. As cases continued to be reported daily, the South African Government imposed a hard lockdown on the population on March 23 for 21 days effective on March 26 2020. The officially confirmed cases had increased to 554 with zero deaths nationally. The lockdown continued to be extended and adjusted based on recommendations made by South Africa's Ministerial Advisory Committee on COVID-19, with the primary aim being to flatten the curve by reducing daily reported cases and ensuring speedy recovery on infected people. In view of this, universities, colleges, clubs and religious houses, and economic activities involving face-to-face interactions to name but a few were restricted. Accordingly, given the mandate to save the academic year, representatives of both public and private higher educational institutions resorted to putting alternative strategies in place for students and lecturers to continue with their lessons when physical attendance is not feasible.

One of the strategies was a transition from physical attendance of classes to online education, to ensure the limited level of contact with and amongst students while attempting to promote students' learning continuation and growth (Ramrathan 2020; Van der Berg and Spaull 2020; Le Grange 2020). However, it remains unclear to what extent the shift to online teaching and learning affects the quality of teaching and students' learning and which factors are at play in enabling and/or constraining the effectiveness of learning (König, Jäger-Biela, and Glutsch 2020). In this article, we present our autoethnographic experiences of teaching the concept of limits in a first-year Mathematics Education course at the University of Limpopo. Our autoethnographic accounts of teaching the course online address two areas. Firstly, the article addresses the challenges we experienced as lecturers in online curriculum delivery and assessment, which does not only necessitate expertise and skills, but also competence to use the teaching resources made available by the institution. Secondly, it provides a critical analysis of the students' readiness and attitudes towards the learning of mathematics in an online space, which includes the learning gaps brought by the transition to online education, in particular Mathematics Education. Our experiences illuminate that online learning cannot be efficiently used in disciplines such as mathematics education due to challenges that are illuminated in this article.

LITERATURE REVIEW

COVID-19 school closure

In these times of the COVID-19 pandemic, online curriculum delivery has since become a key

teaching methodology and a requirement to ensure teaching and learning continuation across different universities in South Africa. Until March 2020, the usual teaching situation at most South African universities was characterised by students who convened in lecture halls and lecturers who presented their subjects' standard curriculum, often through lecturing teaching approaches. In teacher training programmes, this typical teaching situation is important as lecturers can demonstrate and model the essential skills that student teachers should learn and own for their practice. The national lockdown and subsequently the closure of universities for physical attendance of lectures confronted students and lecturers with an entirely new situation, which to many institutions was an unfamiliar way of teaching (Huber and Helm 2020; Eickelmann and Gerick 2020). While the change to online curriculum delivery through the use of various digital tools and resources made continued teaching and learning possible, the critical issue is the extent to which the alternative means of schooling affect the quality of curriculum delivery, students' conceptual development, and development of skills essential to specific professions.

In relation to the above discussion, previous studies on online curriculum delivery suggest that digital technologies may present new opportunities for education (Li and Ma 2010; Chauhan 2017), and the integration of ICT has become increasingly popular in higher education institutions in recent decades. Despite the potential influence that the use of ICT tools has on learning and teaching, it is important to note that the presence of computer hardware for both teachers and students does not guarantee students' understanding and progress (Li and Ma 2010). Within the South African context, which is characterised by inequalities, far-reaching added value in terms of digital literacy competencies among teachers and students, may not yet be guaranteed. For Maringe (2020), there exists a vast amount of literature on distance education that universities offering contact tuition still have a long way to become acquainted with before they "jump" into online teaching and learning. It should be noted that before March 2020, both students and staff from traditional universities did not quite know how to navigate through learning and teaching in the distance mode. "Mere posting of teaching and learning materials on platforms such as SAKAI without the underpinning Pedagogies is likely to negatively affect both quality and effectiveness of students learning" (Maringe 2020). At the time of writing, there was no research found relating to lecturers' experiences of online curriculum delivery in South Africa, focusing on mathematics education in particular. This highlights the significance of lecturers' reflections on the quality of teaching and learning during pandemics. In this article, we present the emergent personal challenges facing the teaching of a mathematics education course (i.e., Limits of functions) in the ongoing efforts to continue learning through online teaching.

COMMUNITY OF INQUIRY FRAMEWORK

The theoretical framework employed to understand online curriculum delivery and assessment for a mathematics education course in the context of COVID-19 is the Community of Inquiry (CoI) framework, which comprises of three key components: Social Presence (SP), Cognitive Presence (CP), and Teaching Presence (TP) (Garrison, Anderson, and Archer 2000). The CoI framework suggests meaningful learning occurs when there is evidence of sufficient levels of these three components of "presences". In this article, we use the CoI framework to construct meanings on how we created "a deep and meaningful learning experience through the development of three interdependent elements – social, cognitive and teaching presence" (Garrison 2011, 15). It is the interactions of all three components of the framework that help us describe and discuss our personal experiences and produce the educational experience for our students as illustrated in Figure 1.

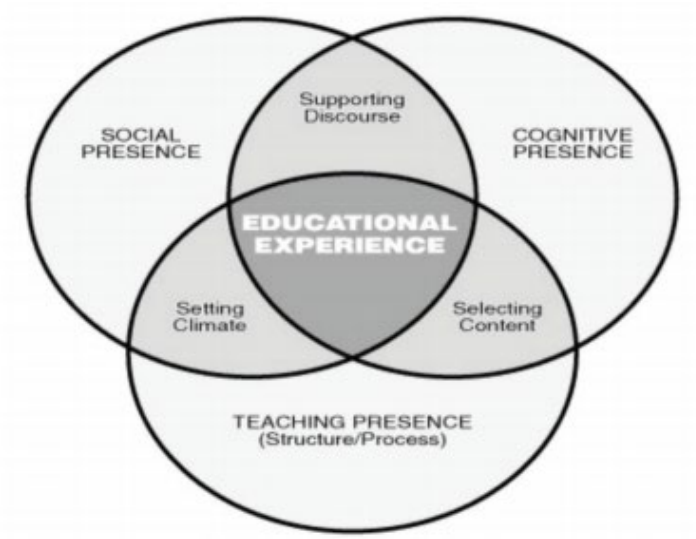

Figure 1: The community of inquiry framework (Garrison, Anderson, and Archer 2000)

SP refers to the degree to which students' true selves are projected and perceived in an online teaching and learning platform (Anderson, Rourke, Garrison, and Archer 2001; Lowenthal and Snelson 2017). This presence is measured in three dimensions: group cohesion, open communication, and emotional expression (Garrison, Anderson, and Archer 2000). During the teaching and learning of the concept of limits in a mathematics education course, this kind of engagement depends upon our ability and students' ability to work the tools of the learning platform, to ensure effective learning, and teaching of the subject. Helping students with the technical challenges during teaching and learning as well as during assessments is an important part of online teaching and learning to maximise students' success in learning and construction of worthwhile knowledge (Anderson 2008; Lee 2014). Considering that the students in the

course are first-year students, with varied experiences of using technological tools due to exposure or lack thereof, the first step was to orient/familarise the students with the learning platform, Blackboard in our context. Accordingly, we used an environment acclimation scaffold to familiarise the students with the learning environment. Notwithstanding the need to help the students with their technical problems, it is important to note that there were some instances we as lecturers were confronted with technical problems during teaching and assessment tasks designing processes. Thus, in our descriptions and discussions of our experiences, we also focus on the technical challenges we experienced as lecturers and the impact the challenges had on the quality of our instruction.

TP entails our direct and indirect roles as lecturers in the design, direction, and facilitation of a learning experience, in this article, the learning of limits (Anderson, Rourke, Garrison, and Archer 2001). This component of the framework is viewed as a key determinant of students' perceived learning, satisfaction, and sense of community in learning (Garrison and Arbaugh 2007). This form of presence comprises three dimensions: instructional management, building understanding, and direct instruction. Instructional management focuses on the design and organisation of the online lesson session, building understanding is about the process through which course presenters facilitate the discourse for the subject, to help students develop meaningful knowledge and skills, and direct instruction entails the teaching process whereby lecturers use explicit instruction to teach specific skills to the students (Anderson 2008; Garrison et al. 2000; Garrison and Arbaugh 2007). In this article, these were espoused as the base for analysis of teaching and learning processes online. The last form of presence is CP, and is taken to mean the degree to which the students can create meaning through continued communication during the lessons (Garrison et al. 2000; Hosler and Arend 2012). This form allows us to understand learning opportunities and constraints during the lessons online, in helping the students to construct meanings for limits through sustained questions and answers between us and the students. The following section presents the methodological approach we adopted for the article.

AUTOETHNOGRAPHIC METHODOLOGY

An autoethnographic approach to writing focuses on offering descriptions and systematically analysing the experiences of authors to present accounts and understanding of their lived experiences (Jensen-Hart and Williams 2010; Ellis, Adams, and Bochner 2011). In this article, the rationale of espousing this methodology is vested in its nature of challenging canonical research approaches and that it views research as a political, socially- just as well as socially conscious act of constructing educational knowledge. While analysing our personal experiences

of lecturing a first-year mathematics education course, it became important that we looked inward and outward, exposing our vulnerable selves relating to our experiences of delivering curriculum content online during COVID-19. We use the auto-ethnographic approach reflexively to demonstrate the intersections between the higher education context and self, and the personal positioning and the politics of knowledge. Reflexive auto-ethnography is used to identify, describe and discuss the critical personal experiences of teaching a mathematics education course on an online platform as well as the specific challenges we were confronted with while designing and administering assessment tasks. Considering that teaching and learning does not take place in a vacuum, our critical reflections incorporate an understanding of our lived experiences within social, political, and cultural contexts.

DATA COLLECTION AND ANALYSIS IN AUTOBIOGRAPHY

Various autoethnographers (Ellis and Adams 2011; Pelias 2018; Tullis 2017) have recommended the need to use multiple sources of evidence to support personal opinions about the phenomenon researchers are focusing on to generate interpretations and make claims. In this article, we present our experiences of teaching first-year student teachers a mathematics course on the concept of limits as stories, to offer critical insight into the patterns that emerged in our interactions with students, and into the challenges we encountered when teaching the course online. We particularly reflect on and write about how the constraints posed by the online mode of curriculum delivery for both the effectiveness of our teaching and the quality of assessment we developed for the students. It is important to note that we were both insiders and outsiders in the system as we observed our interactions and participation during lectures (Gandhi 2018). To present our autoethnographic accounts of our experiences, we use extracts from our reflections on our lectures and the reflection on the process of planning and administering tests online. According to Frank (1995, 23), “to think with a story is to experience it affecting one’s own life and to find in that effect a certain truth of one’s life”. Thus, we invite you to travel with us and allow your thoughts to adopt the stories, to understand the impact of COVID-19 and online curriculum delivery has had on the quality of mathematics learning in our first-year mathematics education course.

ETHICAL CONSIDERATIONS ON AUTOETHNOGRAPHY

Ellis (2020, 42) states that “Autoethnographic stories of our experiences, are not wholly our own; they implicate relational others in our lives”. This statement addresses the notion of relational ethics, which necessitates that in offering personal narratives relating to our experiences of a particular phenomenon, we need to make ethical considerations, especially

when speaking of others in the stories. In this article, we do speak of the students in describing and discussing our experiences, however, we do not mention any names or identifying information. In offering the accounts of our experiences, we talk about the students as a group to ensure maximum protection of the students' identities. Concerning this, Tullis (2013, 4) argues as researchers and writers, we should seriously consider our "responsibilities to intimate others who are characters in the stories we tell about our lives". Thus, in the descriptions and discussions of our experiences of teaching a mathematics education course online during COVID-19, we protect the true identities of our students by talking about them as a group. The following section discusses our critical experiences of teaching and assessing limits of functions for pre-service teachers online.

FINDINGS AND DISCUSSIONS

Mathematics learning, teaching and COVID-19

Much research has been conducted on barriers caused by online teaching and learning in non-pandemic educational situations (Ali and Magalhaes 2008; Eady and Lockyer 2013; Karasavvidis 2010). While this is the case, existing studies did not offer insights into online learning and teaching of mathematics in South African Higher Education. In the current article, to illuminate the challenges and obstacles we faced in teaching Mathematics Education during the pandemic, we focus on teaching and learning challenges and university challenges. The major obstacles we faced in our online teaching were the lack of availability of adequate features in the academic portal adopted by the institution, the limited interaction during the sessions between us and the students as well as the limitations in writing mathematical symbols to facilitate effective explanations. The following sub-sections focus on these obstacles and detail how each of the three obstacles dwindled the quality of Mathematics Education teaching, learning as well as assessment in our teacher training program.

Limited interaction during learning

The virtual teaching and learning space that we created through Blackboard allowed us to interact with our students to ensure that teaching and learning continued. The interactions are such that we shared the teaching slides, highlighted the important aspects of the concepts at hand, and invited students to engage with us on sections that did not make sense to them or where they experienced challenges. However, only few students interact with us during teaching and learning, ask questions and contribute to the discussion of the mathematical ideas. Most students do not contribute to the discussions or ask questions, even though there are

present online. The shift to online teaching of mathematics has compromised the students' social construction of mathematical meanings because we do not have control over what students do during the sessions. The student might be logged in but not participating or not in front of the laptop to fully engage with the mathematical ideas presented during teaching. With the assumption that the majority of the students come to university with knowledge gaps spanning over the previous levels of schooling due to poor teaching of the subject (Spaull 2013), we find the limited participation to be concerning, especially considering the goal of enabling student teachers' epistemological access to mathematical concepts (Nkambule and Mukeredzi 2017).

In teaching the concept of the Limit of functions, we expected our students to verbally, numerically, algebraically, and graphically represent Limits. They should also be able to follow the same approaches to determine when a function is continuous at a point. When a student verbally expresses the idea to us, we can hear if the student is correctly representing the concept or not. For example, if a student is reading the graph and making conclusions based on the interpretations of the observations, we are to tell if the student is having misconceptions or not and provide them with formative feedback to clarify their misconceptions. The reluctance of students to share their responses on the virtual teaching and learning platform or sharing their thought processes during the sessions made it difficult for us as lecturers to monitor and evaluate their conceptual and procedural understanding. Thus, the poor interactions during the sessions made it unmanageable for us to understand students' thinking and meaning-making during the teaching and learning processes. The only time that we can have a sense of what students can or cannot do is when we administer tests or assignments. Although the challenges identified from those assessments would be formatively used to improve their construction of knowledge, by then it would be late to improve their continuous assessment marks. The following section addresses the challenges that we experienced while administering assessments online.

Assessing students online

One of the big challenges we faced during online teaching and learning in the context of COVID-19 was the evaluation and assessment procedures of students' understanding. As indicated earlier above, considering that students were not allowed on campuses, we had to teach and assess them using Blackboard as an online platform. This brought about challenges in designing and administering different assessment tasks for limits of functions online. Notwithstanding the challenges, we configured strategies to continue carrying out assessment activities to get the semester content over the line. The following sub-sections describe the

nature of the challenges we experienced and the implications for pre-service teachers' learning of mathematical contents.

Setting questions to be answered through available software

As part of their learning, pre-service mathematics teachers should learn and develop procedural fluency to ensure that once they are qualified, they can help their learners develop such competency (Killen 2015). According to Al-Mutawah et al. (2019), good procedural fluency enables individuals to select and apply appropriate procedures correctly for various mathematical problems in different situations. Normally, getting a clear demonstration and understanding of students' procedural fluency was achievable through making them write assessments under "exam conditions" in which they were supervised. In view of this, due to the limitations on the Blackboard teaching and learning tool and lack of supervision as the students were writing, it was not possible to set questions that allowed students to demonstrate their procedural fluency to problems of Limits of functions as the tool was configured to accept True/False, Multiple Choice, and single numeric answer questions. Accordingly, to ensure that the taught content and skills were assessed, we resorted to making the questions to be in the abovementioned formats. This limited an opportunity for us as lecturers to obtain data about areas of work where students faced difficulties, and in turn constrained the identification of the areas of work that required re-teaching. Below are two typical examples of questions wherein we expected students to show their understanding of and select appropriate mathematical procedures and carry them out effectively and fluently.

Evaluate the following limits

a) $\lim_{x\to -2} \frac{x^2-4}{x^3+8}$

b) $\lim_{x\to \infty} \frac{3x^2-x-2}{5x^2+4x+1}$

Example of questions on Limits of functions

It could be argued that for learners to answer the questions in the True/False, Multiple Choice, or one-word answers they would need to first apply specific procedures to get the answers. However, in our case, we soon realised that the students had discovered online calculators that can perform the procedures for them and even show them the steps to solve the problems. Before we could administer the first test for the module, one student sent the following email:

"Dr, since there are literally softwares on the internet that can differentiate and integrate,

> practically do everything with full steps. They can compute limits to drawing graphs. Are we going to write our examination online without supervision?"

This email made us aware that as mathematics teacher educators, we are faced with a quandary of ensuring that our student teachers learn and own procedural skills and them getting correct answers through the use of external tools such as online calculators. In the context of CoI framework, this discussion links strongly with the component of Cognitive Presence, as the availability and reliance on online calculators to do the thinking for the students results into a lack of creation of mathematical meanings and demonstration of students' thought processes (Hosler and Arend 2012). For instance, for the two questions that required students to evaluate the limits earlier, students can easily plug the problem into the online calculators and generate the answers without engaging in thinking processes to answer the questions. Thus, we argue that the novel Corona Virus pandemic is causing disruptions in our ways of thinking, ways of knowing about the preparation of mathematics teachers. COVID-19 and online curriculum delivery creates pedagogical limitations for fostering typical mathematical processes and assessment, especially considering students' positionality about what teaching and learning at university entails.

Although there is a dearth of literature detailing the dilemmas of assessing mathematical contents and skills in an online space, our experiences highlight concerns about the quality of mathematics teachers we are going to produce for the system that is argued to have poor quality and unqualified teachers (Spaull 2013; Mbhiza 2021). Also, what is emerging from our experiences is that the stereotype of what university learning entails has evolved drastically under COVID-19 conditions and restrictions. Without generalising, students do not treat assessment to be for the purpose of learning and/or for learning, but to get the right answers, even without conceptual rigor and procedural fluency. While institutions, lecturers, and other higher education personnel are busy configuring strategies to deal with the COVID-19 situation, adjusting plans to meet the conditions of online teaching and learning, and putting some lenient policies, students on the other hand are busy thinking of an easy way out, to ensure that they pass. In essence, we argue that learning and assessing mathematics students in an online space could result in a lack of facility in student teachers thinking mathematically and this might subsequently lead to having mathematics teachers with limited content and procedural knowledge in the near future.

Collaboration to cheat: WhatsApp groups and physical meetings

This section details how students saw the gap in unsupervised and uncontrolled online

assessment as an opportunity to take the easy way out through sharing answers on social media platforms such as WhatsApp and/or gathering together under one room to exchange answers. Previous research focusing on online curriculum delivery has highlighted the importance of building online learning communities that are collaborative, in which students are constantly and actively engaged (Espasa and Meneses 2010; Kuo et al. 2014). Cross (1998, 4) states that learning communities involves "groups of people engaged in intellectual interaction for the purpose of learning". While we believe that students' interactivity in online learning environments plays a significant role in students' academic achievements, understanding, as well as persistence in their courses, our experiences of teaching mathematics education online, revealed the collaboration to cheat. When administering the test on Limits of functions, we noticed a tendency among the students to engage in discussion in the social instant messaging application WhatsApp, removed from our direct supervision and involvement to exchange answers to test questions. Our experiences of teaching and assessing students' mathematical learning online revealed the drawback of online curriculum delivery and assessment to be the intensifying of plagiarism practices.

The students in our case did not only use this communication tool to collaboratively learn mathematical concepts and skills but to cheat in the assessment. Church and de Oliveira (2013) state that WhatsApp has gained prominence due to its advantages such as, being able to send instant messages to an individual and/or groups simultaneously, low-cost, and the privacy it offers. The students in our course used these benefits to cheat in real-time as they continued to answer test questions on Blackboard. Our experiences resonate with findings from previous studies that demonstrated that the present generation of students seem to hold a fluid perspective of what unethical behaviour entails compared to students in the past (Gulli, Kohler, and Patriquin 2007; Troop 2007). While the use of the communication tool could be considered as creating learning communities to enable information sharing and collaboration to learn difficult concepts, the cheating mechanisms students used do not only impede on the reliability of the assessments but the quality of their conceptual understanding as teachers in training. Our experiences resonate with Adedoyin and Soykan's (2020, 5) iteration that "in online learning, assessments are often carried online whereby instructors are limited to proxy supervision of learners making it impossible to regulate and control cheating".

Given the Community of Inquiry framework espoused for this article, we acknowledge that the creation of the channels of communication among the students could be regarded as Social Presence as it resonates with the dimensions of group cohesion, open communication as well as emotional expression (Lowenthal and Snelson 2017). However, in our case, we argue that online teaching and learning exacerbates academic dishonesty and lowers the academic

rigor, the development, and retention of mathematical knowledge in our course. On the same issue, Howe and Strauss (2003) argued that millennial generation students fail to distinguish between traditional tendencies of cheating and contemporary concepts of information morphing. Thus, as it is with our experiences the students failed to recognise the traditional conceptualisation of academic dishonesty as they exchanged answers to the test questions.

Whereas the above discussion addresses students' cheating in online assessment through the use of WhatsApp, we also realised that conversations that students had gathered in one place to write the assessment as we had asked them to remain online on Blackboard Collaborate as they continued writing. "Mistakenly", some of the students were unmuted during the test and we heard them seeking assistance for answering specific questions amongst each other. This further made us aware that the students were using "multiple streams of cheating" in the assessment, to ensure that "no student was left behind". Considering that these students are pre-service teachers, our concern is that they are not making efforts in learning the mathematical skills, concepts, and processes to ensure that when they are qualified as teachers they will possess the knowledge such that they will enable their own learners' epistemological access to mathematics knowledge (Lotz-Sisitka 2009; Nkambule and Mukeredzi 2017). Emerging from our experiences is that we cannot fairly administer mathematics assessments, which include affective and cognitive aspects in an online teaching and learning environment. It was challenging to administer an effective and fair assessment of students' understanding of mathematical contents because of the intervention of fellow students who provided answers to the test we gave the students, both via WhatsApp and during the meetings students arranged to collaborate to cheat as discussed above.

CONCLUSION

Our experiences of teaching and assessing mathematics education students online, therefore, reveals that the shift to online teaching and learning as a result of COVID-19 evidently vitiates the quality of mathematics teacher training, especially conceptual and procedural development or learning for understanding. How the students have positioned their social presence in online learning suggests that learning to own mathematical skills and knowledge is of little concern for them, as in the main, mathematics education learning entails passing without having to engage in mathematical thinking and creation of meanings during assessments. The foregoing discussion calls for us to critically reflect on the purpose of higher education internationally, which remains highly contested. While some researchers emphasise the idea of the higher education institutions to be underpinned by the values of epistemic plurality, democratic tolerance, and critical engagement (Badat 2017; Heleta 2016), our experiences of teaching

mathematics education online show that students are less concerned about critical engagement and development of academic rigor.

As students lean more towards the online softwares and exchange of answers via applications such as WhatsApp, our experiences to some extent reveal a risk of losing the dimension of the body lecturer and teacher preparation processes, in favour of the online calculators in the transition from traditional teaching, learning, and assessment, involving physical presence, to e-learning. The key questions emanating from the emerging challenges are as follows:

- How best can we assess the different mathematical proficiencies during this pandemic?
- How can we ensure and maintain quality in how we assess students in mathematics?
- Do we need to rethink how to define and explain what mathematical understanding is given the challenges brought by online teaching and learning?

Although we cannot generalise our experiences of teaching mathematics education online, it is important for those involved in teaching and implementing online mathematics courses to configure strategies to uphold academic integrity and think of alternative practices for content delivery and assessment during the pandemic.

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