

Exploring student teachers' perceptions of the influence of technology in learning and teaching mathematics

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Rapid global technological developments have affected all facets of life, including the teaching and learning of mathematics. This qualitative study was designed to identify the ways in which technology was used and to explore the nature of this use by a group of 52 mathematics student teachers. The participants were pre-service Mathematics students who were enrolled for a Mathematics module at a South African university. The research instruments were an open question and a semi-structured interview schedule. Saxe's framework was used to analyse the data. Some benefits of mathematics software were found to be the provision of different representations, dynamic visualisation of concepts and variation in mathematical situations. It was also found that students used technology more often in their own learning than in their teaching, because the schools did not have many resources. It is recommended that the education department prioritise the provision of specialist mathematics software that can be used to improve learning outcomes in mathematics.

Keywords: Dynamic geometry software; mathematics learning; mathematics teaching; Saxe's framework; technology

Introduction

The face of mathematics instruction and learning has been transformed by the widespread use of graphics calculators, computer algebra systems (CAS) and other computer technologies (Forster, 2006). Clearly, the extent to which technology influences the learning of mathematics depends on the extent to which the teaching utilises technology. However, Tall (2010) cautions that changes in learning are caused by a variety of factors of which the technology is only one. The use of technology requires research and careful planning in order for it to achieve potential benefits. Tall (2010) reported that some students using a computer algebra system to find the derivatives of functions, when asked for an explanation of differentiation, responded by providing the sequence of key-strokes that were necessary to get the result. Tall (2010) cautions that the use of technology must be planned, so that students do not simply replace one procedure holding little conceptual meaning with a different but equally meaningless procedure.

Although much research has been conducted regarding the use of technology in learning and teaching mathematics (Forster, 2006; Lei & Zhao, 2007; Monaghan, 2004) there is still only limited research available about how technology has been taken up in developing countries (Chigona, A, Chigona, W & Davids, 2014). The study on which this article is based sought to contribute to addressing this gap. Accordingly, the research question that underpinned this study was: how has the availability of technology influenced the teaching and learning experiences of a group of pre-service student teachers from a South African university?

Developing countries may be sometimes beset with problems such as poorly managed schools and education systems, teachers with inadequate support and training, as well as limited access to efficient technological software. This study, which investigated the use of technology by young student teachers, can contribute to the knowledge base that emerging resource economies such as South Africa need in order to make important policy decisions. It is hoped that the study will add to knowledge about the enabling and constraining factors associated with the use of technology in the teaching and learning of mathematics in South Africa. It has to be noted, however, that not all developing countries are homogenous, and hence, that the extent of particular problems may vary across different developing countries.

Literature Review

According to Forster (2006), studies about the effect of technology in learning outcomes in mathematics do not always concur. Some studies have reported an increase in rich learning outcomes, while others have identified shortcomings in the conceptual understanding developed by learners whose learning is dominated by these technologies. Benefits of computer technologies include fast, accurate calculations, generation of graphs, processing of multiple examples, symbolic manipulation, and solutions to equations. Forster's (2006) view is that access to these facilities provides valuable support to the learning of mathematics by allowing students to focus on mathematics properties and relationships, instead of their being stonewalled by the tedium of completing complicated calculations.

The role of structured variation in learning mathematics has recently come under scrutiny (Marton & Booth, 1997; Scataglini-Belghitar & Mason, 2012; Watson & Mason, 2006). Increasing complexity in mathematics concepts is often associated with an increasing variation within and between quantities, procedures and relationships. Watson and Mason (2006) assert that if learners are exposed to structured or structural

experiences aimed at exposing underlying mathematical form, their ways of working can be shifted to higher levels. These authors identified mathematical variation as a scaffolding tool that can be used in mathematical activities to shift learners' thinking towards a more conceptual orientation. Scataglini-Belghitar and Mason (2012:932) focus on "dimensions of possible variation" which refer to "features, aspects and parameters that can be changed in an object whilst remaining an example of a concept".

Any search for approaches that can lead to increased perceptions of variation in mathematics leads naturally to the use of technologies, because of the opportunities offered by much of the mathematics software. Programmes or applets which allow students to manipulate graphs and simultaneously view changes in a table, have been observed to benefit the learning of function properties (Forster, 2006). Steketee (2010) calls for more attention to a dynamic approach to algebra that emphasises the role of variables as changing quantities, and uses the behaviour of functions to characterise the relationships between varying quantities. Steketee (2010) shows how the use of dynamic geometry software can be used to develop a dynamic approach to algebra. Similarly, Tall (2010) calls for an interrogation of how calculus could be taught by making use of software. Tall (2010) uses the term 'dynamic visualisation' to capture the possibilities of software to present a changing view of the tangents to a curve as the graph is magnified to consider increasingly small segments. He suggests that this dynamic visualisation provides an embodied perception of the changing slope, which leads to an understanding of the process of differentiation. By linking the dynamic visualisation to the symbolic operation, learners can develop an embodied meaning of the difference quotient in finding the derivative.

Linking different meanings associated with different representations is central to developing a deep understanding of a mathematical concept. Stylianou (2010) argues that students should be fluent users of representations and instruction should include opportunities for students to form connections across a variety of representations. The author notes that the

new emphasis on representation has brought to the surface the complexities of representation not only as an individual or cognitive practice [...] but as a social process, closely related to students' understanding of the concepts and situations being represented (Stylianou, 2010:328).

Researchers agree that the use of technologies in the mathematics classroom provides valuable opportunities for accessing and understanding different representations of concepts (Forster, 2006; Steketee, 2010; Tall, 2010).

However, as teachers are increasingly expected to take on the integration of technology into the mathematics classroom, one factor that can cause problems is the students' skill in the use of computer technologies. Chigona et al. (2014) found that teachers in the Western Cape were demotivated when they found themselves teaching the technology instead of teaching with it. They did not have the freedom to take on responsibilities that would have given them greater control over the technologies that were available. According to Artigue (2002), the issue of instruction in tool use in secondary school is an area requiring attention. She asserts that learners need direction from teachers about technical aspects of tool use and teachers need support and direction about which techniques they could encourage and how they could do that. Forster (2006) asserts that students' technical understanding is an important factor that must be considered in a classroom that employs technology. He defines technical understanding as "computer-specific and additional to the understanding on which by-hand approaches rely" (Forster, 2006:148). He argues that prior to any computer-based activity, the status of students' technical understanding should be assessed. Technical understanding encompasses different phases of technology use such as the input of information, the selection of procedures carried out by students, and the interpretation of outputs.

Lei and Zhao (2007) explored how technologies used in a middle school could improve learners' learning outcomes. The study found that spending some time on computers could help learners increase their learning outcomes. However, too much time on computers could be harmful, because they spent more time using computers in ways not likely to increase their academic achievement. It was the quality of technology use that was a more critical issue than quantity of technology use. Technology uses that had a positive impact were those related to specific subject areas and those that emphasise student construction (Lei & Zhao, 2007).

Methodology

The study was qualitative in nature, because of the focus on the interpretative dimensions. A class of pre-service student teachers were invited to participate in the study. Of the class of 68 students, 49 provided written responses to a questionnaire consisting of four questions that probed their engagement with technology in the learning and teaching of mathematics. A further three students volunteered to participate in a semi-structured interview, which probed the same issues as the questionnaire.

The questions were: 1. How have you used technology in your teaching practice? 2. How have you used technology in your own learning of

maths? 3. What are some ways in which the availability of technology benefited or negatively affected the way you teach Maths? 4. What are some ways in which the availability of technology benefited or negatively affected the way you learn Maths? The data generated by the written feedback given by the student teachers were analysed through the process of content analysis which is used to “[cast] additional light on the source of communication [and] its author” (Cohen, Manion & Morrison, 2007:165). In carrying out this content analysis, the students’ written comments were broken down into ‘descriptive units’ (comments conveying a single coherent meaning) so that each unit could be coded as advised by Henning, Van Rensburg and Smit (2004:128) that data “are broken up in order to be classified”. Initially, the technique of open coding was used, which refers to “[a] first coding of qualitative data in which a researcher examines the data to condense them into preliminary analytic categories” (Neuman, 2011: 461). The process of open coding was followed by axial coding, where these codes were grouped and clustered together, using the four parameters embedded in Saxe’s framework as an organiser. This phase of the analytic process consisted of movements back and forth from the data to the framework, while making judgements of the fit of the framework. These movements are in line with Erickson’s (1998:1171) description of qualitative research where “researching is to seek and seek again, recursively”. In terms of ethical procedures, informed consent was obtained from the participants before proceeding with the study. Participants were guaranteed anonymity, because in the analysis and reporting, only numbers and not names were used.

Theoretical Framework

Saxe’s model of goal-linked practice emerged in his attempts to “analyze [sic] the cognitive work and developments that are constitutive of practices” (1991:218). The model is essentially an activity theoretical approach, which takes human practice as central. The framework has, as its central feature, the ‘emergent goals’ which are shaped by as well as shape four parameters (prior understandings, convention/artefacts, social interactions, activity structures). Saxe (1991:218) notes that “goals are understood to be emergent in the sense that they form and shift in practice”. The goals are small, may be unconscious, emerge, shift and take new form as a result of the knowledge that individuals bring into practices.

In this article, we look at a group of pre-service Mathematics students’ practices of teaching and learning Mathematics using technology. As prospective Mathematics teachers, their current focus is learning in order to teach Mathematics as a subject. Saxe’s (1991) framework offers a useful

lens to understand the ways in which technology is used by the student teachers in their learning and teaching experiences.

Some of the emergent goals associated with teaching Mathematics using technology include mediating the mathematics, keeping the children’s attention, making the task of the teacher easier, and making the content accessible. With respect to learning mathematics using technology, some of the emergent goals may include developing an understanding of the content, and being able to complete assignments or other assessments.

Activity structures are the general tasks, which must be accomplished in the practice, as well as the task-linked motives. The practice of teaching may include some general tasks, such as preparation of lessons, designing lesson activities, and making assessment activities. The practice of learning may include tasks such as finding solutions to problems, understanding mathematical concepts, and investigating properties of geometric figures, to name a few.

Prior understandings are “understandings that individuals bring to bear on cultural practices which both constrain and enable the goals they construct in practices” (Saxe, 1991:18). In this case, some of the prior understandings of the pre-service teacher concern their previous experiences with technological innovations in their own learning and in their own teaching experiences. They also concern their learners’ understandings and use of technology.

Social interactions are the interactions around which the practice takes place. In the practice of teaching by the student teachers, the social interactions centre on the teacher-learner interactions, and learner-learner interactions. In this study, it could also include teacher-technological tool interactions as well as learner-technological tool interactions. Considering the practice of learning by the pre-service students, the interactions could be student-student, lecturer-student and student-technological tool interactions.

Conventions and artefacts consist of “the cultural forms that have emerged over the course of social history” (Saxe, 1991:18). These artefacts influence the ways in which teaching and learning is practised. In the case of the pre-service teachers’ use of technology in teaching, this refers to the tools, hardware and software that are actually used to mediate the learning by their learners. In the case of the pre-service students’ use of technology in learning mathematics, it refers to the tools, hardware and software that are used by the students to facilitate their own learning of mathematics.

Results and Discussion

The presentation of the results is arranged according to the components of Saxe’s (1991) model, consisting of the four parameters and the ways in

which the emergent goals have been influenced by the available technologies. In citing written and verbal responses by the participants, the codes S1 to S52 are used, where S1 to S49 represent the student teachers who provided written responses to the questionnaire, and S50 to S52 represent the three interview respondents. Note that all students' responses are presented verbatim, without any changes to the grammar, spelling or the vocabulary employed by the participants.

Conventions and Artefacts in Learning and in Teaching

In terms of their own learning, 13 students reported the use of YouTube and 12 students wrote about watching online videos that explained the proofs of well-known problems from their mathematics lectures. Thirteen students specifically mentioned the use of dynamic geometry programmes such as The Geometer's Sketchpad (GSP) and GeoGebra, and two spoke about the indispensable use of their calculators, which made their task easier. For example, S2 wrote: "you cannot calculate $\log_{50} 35$ in your head, and you definitely need a calculator for that".

With respect to the teaching of Mathematics, the use of technology was much more limited. Many (16) of the pre-service teachers reported that they had done their teaching practice in rural under-resourced schools, and therefore did not have access to much technology. Seven students reported that they took their own personal laptops along to the schools so that they could illustrate some aspects of mathematics to their learners that required the software. There was just one student who wrote about having access to an interactive whiteboard. For 19 students, the only technology they used were slides on overhead projectors, and two students reflected that the only technology they used was the photocopying machine to make copies of notes.

Activity Structures

In terms of the teaching experiences of the students, most (16) indicated that they used technology for lesson planning or for doing research into how a concept could be taught. There were 15 who wrote about using technology to find explanations and solutions to problems. Some students (3) mentioned the value of using the dynamic geometry software to show equal angles, and to show points of intersection. For example, S12 wrote: "we can see where $x = 0$ and $y = 0$ and what it means in the graph". The student's comment conveys the idea that the technology made it possible to bring two different representations (graphical and symbolic) together. By looking at the functions $f(x)$ and studying the points of intersection of $f(x)$ with the axes, it was easier to match the picture with the solutions to the equations $f(x) = 0$ and $x = 0$.

One student (S51) explained how the GSP programme was used to direct her learner's attention to the underlying structure in mathematics objects:

I used Sketchpad to show them [...] the three main diagrams for angle at the centre. On that sketch itself you could click on something and change the diagram the inside part of it and, no matter which way it went, they could see from the calculation that the angle at the centre was always twice the angle at the circumference, because they were under the impression that if it is orientated at [sic] different ways, that your angle would be different.

The description by S51 above concerns her use of the GSP to demonstrate to her learners that as the angles in the diagrams were varied, the figures looked different, but the relationships between the respective angles remained the same. This is also an example of what Tall (2010) refers to as dynamic visualisation, which presents a changing view of angles at the centre.

In terms of their own learning, students reported a much wider use of technology than they did for their teaching. Twenty-five students mentioned that the use of online videos helped them revisit explanations or proofs that they did not fully grasp during their mathematics lectures. This process is explained by student S2: "if I don't understand a section, I go to Youtube and watch videos that are illustrating more that what was happening in our class". Examples of sections found online by student S7 included proofs by induction, proof of irrationality of certain numbers as well as number theory. The benefits of watching an online video meant that unlike what happens during the lecturer's explanation, a student could "pause and rewind to understand everything in my own pace" (S4).

Social Interactions

The students used technology mainly for demonstrations and explanations, rather than for designing class activities or investigations. There were 15 students who spoke about using technology to provide explanations, while only two students wrote about investigations using technology. This distinction suggests that many of the teacher-learner interactions experienced by these students were mainly teacher-directed based on exposition and demonstrations.

In terms of their own learning, recent accessible social media platforms have changed the ways in which they interact with their peers. One student (S52) spoke about how they used WhatsApp groups to ask their peers for help and to share solutions of problems:

A group of us [...] were talking about an assignment that we had to do and we were talking about how to work out the different questions; and there were some questions we could not work out, so we were saying that we could share the solutions

later, and instead of sharing individually, we could do a group-share by using Watsup [sic].

The student explained that the convenience of the WhatsApp group was the fact that “most people have it because it is cheap and convenient and compatible with all smartphones”. This method of virtual peer communication is an alternative to the traditional ways where students who work in groups need to meet physically and discuss the work.

Prior Understandings

In terms of technology use in teaching, the students identified learners’ exposure to technology as an issue that both facilitated and limited the learners’ engagement with technology-based lessons. Three students felt that their learners had grown up in a technological environment and that was the reason why they (as teachers) needed to embrace technology as a necessary means of keeping up with the new generation of learners. Five students wrote that their learners’ poor technological skills limited their scope as teachers. Their learners did not have sufficient technical understanding (Forster, 2006) to allow them to achieve the mathematics outcomes that depended on fluent use of the software.

Five felt uncertain about their own skills, and wrote that if teachers did not have sufficient technical skills, it would create more problems. S6 wrote about the challenges of trying to keep up with technology: “... technology keeps changing new and again which made us difficult to adapt as technology advances”. In some studies, it has been argued that technical understanding of both teachers and learners must receive attention in order to increase the integration of technology into the Mathematics classroom (Artigue, 2002; Chigona et al., 2014; Forster, 2006). The comments from these students support the researchers’ argument that teachers and learners should have access to technical support and training so that they can improve their technical understanding.

Many students (11) felt that technology could be used to make up for gaps in learners’ knowledge by providing a variety of strategies, examples and representations that could be used to deal with mathematics concepts. For example, it could allow for learners with different ways of understanding to be exposed to different representations of concepts, and it could also provide many examples that could be used. S51 spoke at length about this issue:

... where if something does not gel well with one person it may gel with another person [sic]. Because we have 35 children in the class, maybe out of that 35, 20 might like to learn in a certain way. The other 15 [...] because of the way [...] in which the teacher conveys the topic, they don’t quite get it; not because they are stupid, not because they can’t understand, but simply it’s not the way they like to learn. Because of that I wanted to accom-

modate for [...] I gave them written tasks, I gave them practical tasks, and I gave them things from the software to do and make them experiment [...] all the different learners to be accommodated.

The students’ prior experiences with technology were identified as an issue that affected the extent to which they were personally able to take ownership of technology in their own teaching. Some students felt at a disadvantage because they had not been exposed to technology earlier. For example, S9 wrote:

[N]ot having technology being made available for me to use earlier in my life, such as while I was still in school, it would have made a huge difference in terms of my [learning].

Similarly, S7 was disappointed that her lack of fluency with GSP “has left me behind in Maths 310 because of not [being] familiar with sketch pad”. The reason why the student did not have much experience with GSP was “because the programme was expensive”. Student S50, like S7, was frustrated by his lack of fluency in GSP, which prevented him from getting to the result when he tried to test a theory: “and I get it wrong and it does not work out. I am not getting the desired result ... and I was trying to do all of those things”. S50 was clear that the lack of exposure to technology in his schooling limited him in the use of technology in both his learning and teaching:

I honestly felt that I am not a person that can look at computer and learn from it. If you are doing it on a board [...] I learnt far more from there than sitting in front of a computer.

In contrast, S51 said:

From my Grade 10 to matric year majority of all my lessons were very interactive, we used to have PowerPoint presentations and video lessons all of that [sic]. It was very interactive, so it changed the whole learning experience completely.

Her (S51’s) exposure to technology influenced her approach to teaching Mathematics, where she used software to show that “math [sic] can be interesting, it can be fun and interactive”.

Emergent Goals

How were the emergent goals for learning and teaching affected by the availability of technology? Students reported that their learning experiences were influenced by the extent to which lecturers engaged with technology. The data also revealed that technology was perceived as making their work easier; however, it sometimes made them a little lazy to work out problems on their own. Students spoke about the importance of sketching graphs by hand and doing a lot of practice. Technology was also perceived as a vehicle to help learners understand the effect of varying some parameters while holding certain parameters constant – in particular, mathematical situations. These themes are detailed below.

Effective use of technology can improve the learning experiences

Students reported a differential take-up of technology by university lecturers in their own lectures, and this influenced the students' learning experiences. One student (S51) related how boring her lectures were, because most lecturers did not use technology to liven up the lecture:

When we come to campus, half of the time, we don't like going for lectures because it is so boring. There is just someone standing there and talking non-stop [sic]: there is no interaction as such.

However, when lecturers used technology it did not necessarily imply more positive learning experiences. It was the quality of the use of technology that made the difference. For example, merely presenting complete proofs on PowerPoint was not judged as useful by S4, who wrote:

It has made learning Maths less interesting if the lecturer/teacher already have the questions and answers already [sic] shown on the Powerpoint, rather than having the question, and then work out the answer on the board.

If a lecturer used technology in innovative ways to make the content more accessible, then students responded more favourably. For example, S47 wrote:

I believe that passing Mathematics well depends on how well the lecturer demonstrates [...] Prof. showed us plotting of graphs, using graphing calculators [...] now I am using what I was taught in 320 and Maths is simple and understandable.

Student S47's learning experiences with a lecturer who actively utilised technology to mediate the mathematics were very positive, and had an impact on his understanding of the mathematics. Hence, the quality of the use of technology by instructors is a factor that influenced the quality of the learning experiences of the students. As in the case of Lei and Zhao's study (2007) which found that it was not the quantity, but the quality of technology use that made a difference to children's learning outcomes, in this case, students agreed that technology must be used effectively to improve the students' learning.

Technology eases the tasks of teaching and learning

Some students (11) noted that technology made their work easier in various ways. There were seven students who wrote about the ways in which technology improved their understanding in geometry, and 13 who pointed out that programmes like GSP made it easier for them to sketch complicated graphs and to discern the underlying relationships in the graphs. S52 explained that using technology was easier than consulting a textbook to find the section that they needed to master. With the textbook one needed to "find the textbook, find the chapter, find the page" before one could get to the section one needed, but with

online technologies, one would just google and immediately find different sources.

A large number (19) wrote that the technology made life easier for a teacher and reduced the tedious tasks. The onerous use of a chalkboard for writing notes and explanations was no longer necessary, thus allowing teachers to spend more time on more important tasks. Students also wrote about how it was easier to present alternative solutions to problems using available technology. Instead of writing out the solution by hand, step-by-step, one could just flash the steps on the screen. Eighteen students reported that lessons were made more exciting and interesting, thus keeping the attention of the learners.

Importance of doing the mathematics

Many students (13) wrote that technology sometimes led to laziness on the part of learners. There were 12 students who also acknowledged that technology made them lazy as well. For example, S5 wrote:

It has negatively affected my learning in terms of making me rather 'lazy' to draw some graphs on my own, which leads to forgetting how to solve some problems, or discover my mistakes without technology.

S22 explained that technology could be deceptive, because it made the task seem easier than it was: "I just watch a video and do nothing because I seen that the problem is easy". However, when he tried to write out the proof afterwards he would realise he had a problem: "When I start writing them I don't get them right" [sic]. This comment underlines the importance of 'doing' more instead of only 'seeing'. Many students, such as S50, believed it was important to show learners how to draw diagrams by hand: "even when it comes to diagrams, I try and do it by hand as good as possible so they can see it". This comment shows that the student acknowledged that an important aspect of learning mathematics was writing out a solution by oneself, as well as sketching graphs by hand.

Effective use of technology helps learners see connections between representations

Providing opportunities for learners to link different representations of a mathematics object is an essential task of a Mathematics teacher (Stylianou, 2010). However, activities that are focused on achieving this skill require careful sequencing and much planning. S50, on the one hand, felt that if learners move too quickly to using software to sketch graphs, the opportunities for making connections between the different representations of a function may be lost. On the other hand, in her interview S51 showed evidence of how she used GSP to lead learners to understand connections between the different representations of the angle subtended by an arc at the centre:

I showed them the three main diagrams for angle at the centre. On that sketch itself, you could click on something and change the diagram [...] no matter which way it went they could see from the calculation that the angle at the centre was always twice the angle at the circumference.

As explained by S51, software such as GSP can be used to demonstrate different representations and this is supported by researchers (Forster, 2006; Tall, 2010). However, effective use depends on the teacher's skill and confidence in utilising the software.

Learning as discernment of variation

Steketeer (2010) distinguishes between the ideas of a static representation, which is a snapshot of a situation at an instance where certain variables have a particular value, and a dynamic representation, which permits one to see how quantities change over a period of time. S51 explained the advantage afforded by the software to address this dimension of learning in her interview: "you can see why the proof is done in such a way and why it holds and why it works, because when you [are] changing parameters of your dimensions of your figure the proof still holds".

Watson and Mason (2006) have written about the value of planning mathematics learning experiences, focusing on what varies and what stays constant, in order to help learners discern the properties of the structure under consideration. In her description above, S51 showed a profound understanding of this idea and identified the value of using GSP to observe the effects of changing variables and parameters in geometric figures.

Conclusion

This article explored the perceptions of 52 mathematics student teachers about the ways in which technology was used in their own teaching and learning of mathematics. The students' reports suggest that the use and availability of technology in their lives have altered the landscape within which the learning and teaching of mathematics takes place. Students reported that: access to technology has made their tasks of learning and teaching much easier; they have a greater variety of strategies available; the technology allows them to vary the pace at which they can study; it has given them access to many different resources; it has granted them more independence in learning; and it has changed the nature of communication in which they engage, amongst other things.

Particular benefits of certain mathematics software included opportunities for working with different representations, providing a dynamic visualisation of concepts, and providing variation in mathematics situations to enhance the understanding of concepts. The data also showed that students who had not been exposed to technology early felt disadvantaged. Students such as S7, who

had not been exposed to technology-rich lessons in their schooling, felt that they were at a disadvantage because they felt that earlier exposure would have been beneficial to the way in which they understood the mathematics. S50 too, was taught mainly traditionally and seemed to need the comfort of learning from hard copies and the reduction of distractions of different colours and different types of information. However, S51 seemed to revel in using technology for verifying results and investigating different situations.

The data showed that students spoke more easily about using technology in their own learning than in their teaching, possibly because teaching using technology requires facilities and resources in schools, and these were beyond the control of the student teachers. Many of the student teachers reported that they did not utilise modern technologies in their teaching, mainly because of constraints in the environments in which they carried out their teaching practice. It is suggested that the Department of Education should prioritise the delivery of mathematics-specific technological resources to schools so that teachers might make greater use of such resources in their teaching. Perhaps as technology becomes easier to access in under-resourced schools, the teachers will find it easier to utilise these technological tools. Providing learners access to technology earlier in their schooling will help them become confident users and later on, if necessary, they may themselves become confident Mathematics teachers, who are not afraid of technology.

However the participants reported that it is the quality of technology use that influences the quality of the learning experiences. Hence, it is crucial that sufficient access to technical support must be provided in any rollout of technological resources to help teachers and learners use the technology more effectively. Education departments from developing contexts in particular should not assume that it is sufficient to provide the necessary resources. Without the requisite support, the investment in the technology will not lead to more effective teaching and learning experiences.

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