Responsive and Innovative Pedagogies: Exploring Postgraduate Students' Insights into the Use of Technology in Mathematics Teaching

Jayaluxmi Naidoo

Abstract

Exploring the use of responsive and innovative pedagogies is central in sustaining and improving teacher development at higher education institutions. As lifelong scholars, teachers are invested in preparing and developing a new generation of democratic citizens. To attain this goal, teachers should be aware of emerging trends in education, innovative teaching strategies and responsive teaching tools and resources. This qualitative study, which was located at one university in KwaZulu-Natal, South Africa, explored postgraduate students' insights into the use of technology in mathematics teaching. The study was framed using Shulman's teacher knowledge model, focusing on teachers' pedagogic content knowledge. During the 2012 and 2013 academic years qualitative data were collected from 22 postgraduate mathematics students via interactive workshops, a discussion session focussing on learnings from the workshops, a questionnaire and semi-structured interview schedules. Thematic coding and interpretive techniques were used to analyse the data. The findings of this study provide a glimpse of what is valued in mathematics classrooms; therefore they are important for advancing mathematics curriculum development. They may also be useful to mathematics teacher educators at higher education institutions. Moreover, in view of the role played by technology and mathematics in everyday life, these findings are clearly relevant.

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Introduction

Mathematics plays a key role in influencing how individuals deal with various domains of life (Anthony & Walshaw 2009:147). Mathematics today has a considerable impact on science and society (Aguele & Usman 2007:293): it underpins social development and the global economy at every level; its language is universal and it plays a significant role in one's personal and work life (Vorderman, Porkess, Budd, Dunne & Rahman-Hart 2011:19). However, currently there is global concern about the poor performance of learners in mathematics (Siyepu 2013:1; White Paper 2011a:10). The significant role that mathematics plays in every career path implies that a decline in learners' mathematics results will affect every domain of a country's economy (Raghunathan 2003:290); therefore, mathematics is seen as a gatekeeper for many career paths. The level of proficiency in mathematics has a direct bearing on the economy of a country since the economic wellbeing of any country is reliant on the abilities and knowledge of its workforce (White Paper 2011b:13).

The teaching and learning of mathematics has been a contentious issue throughout the world. Mathematics teachers are constantly looking for innovative and stimulating instructional tools to encourage and sustain learners' attention in mathematics classrooms with the aim of improving mathematics pass rates. One innovative instructional tool is the use of technology in the mathematics classroom since we live in a society which thrives on technology as the foundation of our existence. Not too long ago learners were reprimanded for bringing cell phones to school; however, now schools encourage the use of hand-held devices such as cell phones if it adds value to the learning process in the classroom.

Thus, technological advancements have made their way into the classroom and the use of technology in teaching is regarded as a responsive and innovative pedagogical tool. Shallcross and Harrison (2007:78) point out that the use of technology has increased immensely in education environments. Hence, the study on which this article is based sought to answer the following research question: What are mathematics postgraduate students' insights into the use of technology in mathematics teaching? 'Insights' in this study referred to the postgraduate students' understanding of the use of technology in the mathematics classroom and its relationship to promoting the effective teaching and learning of mathematics.

Postgraduate Students

The postgraduate students participating in this study were in-service teachers who were registered for a master's or doctoral degree in mathematics education. All the participating postgraduate students were teachers of mathematics at primary or secondary school level; hence, they are referred to as in-service teachers. Postgraduate students are an important part of any university's vibrant and active research culture. The PhD (Doctor of Philosophy) degree in mathematics education is a research-oriented degree which does not require coursework. This degree concludes in the presentation of a thesis or a dissertation. The thesis involves making an original contribution to knowledge in mathematics education. In addition, some universities require the candidate to defend their dissertation orally.

The PhD students at the participating university are expected to attend PhD cohort seminars which are held six times a year over six weekends. During these seminars the students are assisted with all stages and phases (from the proposal development and data gathering up to and including data analysis) of their PhD thesis. The PhD students are expected to present aspects of their thesis to their peers and facilitators at each of the six seminars. After the presentations, students receive feedback pertaining to their presentations. The feedback is aimed at assisting students with conceptualising and clarifying aspects of their thesis. All theses or dissertations at this university are undertaken in collaboration with a member of the academic staff called the supervisor. Some students may also have the assistance of a co-supervisor.

Typically, the Master's in Education (MEd) degree requires postgraduate students to construct a thesis in mathematics education. The thesis ought to foreground and demonstrate the student's ability to undertake research and should involve an original investigation. An MEd student can select to do a full thesis or a thesis with coursework. At the university at which this research was conducted, students who are enrolled for a full MEd thesis are encouraged to attend the generic research methodologies and discourses module offered during the first semester of the first year of registration. Apart from this generic research module, the coursework MEd in mathematics education students at this university attend lectures that focus on various issues and trends in mathematics education. One such module focusses on innovative teaching strategies in mathematics education.

Technology in Teaching

It is evident that many factors influence or effect learners' learning (Morony 2009:262); however, learners gain much of their learning and thinking skills from classroom instruction (Cai, Perry, Wong & Wang 2009:1). The classroom milieu is neither fixed nor linear (Anthony & Walshaw 2009:149) since learners are diverse in their backgrounds, needs and aptitudes. Additionally, the knowledge of learners within a classroom can differ widely and gaps in knowledge are distinctive to different learners (White Paper 2011b:6). Moreover, learners today are bombarded with technological information in their daily life; hence, the traditional classroom environment is not suitable for learners in today's society (Yelland 2001:8).

Research has indicated that there are important benefits of using technology in teaching and learning (DelliCarpini 2012:14); thus, information and communication technology (ICT) has become an important tool in educational contexts (Bingimlas 2009:235). The use of ICT in classrooms creates many opportunities for learners to work within a global technological platform. Schools ought to keep up with the technological evolution of daily living since the use of technology in teaching demonstrates encouraging consequences for learners (Niess 2005:150, White Paper 2011b:6). However, despite claims that technology is important in teaching and learning, the use of technology within teaching is still limited (Putnam & Borko 2000:10).

Teachers can now search different internet websites and find various video clips and lesson plans to foster excitement and interest within the learning environment. By using technology in teaching it is possible to create an interesting and stimulating learning environment that seeks to accommodate the different learning styles and different learning abilities of today's learners. The appropriate use of technology in teaching has the potential to transform teaching and learning in schools and higher education (Putnam & Borko 2000:10).

Additionally, technology assists in improving communication, cooperation and learner competence within the teaching environment (DelliCarpini 2012:15, Franz & Hopper 2007:1). Moreover, the use of ICT in teaching may enhance learner achievements and teacher learning (Kadijevich, Kokol-Voljc & Lavicza 2008:5; Mistretta 2005:18). Likewise, the use of ICT in teaching increases the teaching and learning resources that are available to both the teacher and the learner. Technology ought to be integrated into teaching so as to ensure that learners also improve their electronic literacy skills (DelliCarpini 2012:14). Thus, the use of ICT in teaching may be regarded as a responsive and innovative tool in the classroom for both the learner and the teacher.

Teachers and Technology

Teachers are important assets for developing learners' mathematical identities (Anthony & Walshaw 2009:150). To be successful in the classroom, teachers need to be knowledgeable in both their content knowledge and pedagogic knowledge of the subject being taught. Teachers are also required to know how to teach the relevant content effectively. This is referred to as pedagogic content knowledge (Shulman 1987:8). In addition, to use ICT in teaching, teachers are required to be confident and competent in their use of ICT (Anthony & Walshaw 2009:157; Franz & Hopper 2007:6; Mistretta 2005:19; Niess 2005:510). Teachers are required to make intelligent decisions about how technology is integrated effectively within their teaching. Furthermore, teachers are required to assist learners in choosing the correct technological tools and to advise them on the correct techniques to use when working with the selected technological tools (Forster 2006:146). Thus, teachers are required to possess technological pedagogic content knowledge (Niess 2005:510).

Nevertheless, research (Lin 2008:135) has revealed that teachers are not confident or competent in the use of ICT in their teaching. Some teachers fear changes in the work environment while others lack the training, technical support and knowledge of how to use technology effectively in their teaching (Bingimlas 2009:238). Additionally, research has indicated that both learners and teachers have suggested that some barriers to the use of technology in teaching could be related to teacher knowledge and skills (Bingimlas 2009:237-238; DelliCarpini 2012:18). Still, to transform education, teachers ought to become the agents of change (Ertmer & Ottenbreit-Leftwich 2010:267). Schools, communities and government ought to ensure that their teachers are sufficiently skilful and prepared to provide learners with superior learning opportunities (Anthony & Walshaw 2009:159; Mistretta 2005:23). Teachers ought to make a concerted effort in improving both their pedagogic content knowledge (Shulman 1987:8) and their technological pedagogical content knowledge (Bingimlas 2009:240) in order to effectively integrate technology within their classrooms.

Mathematics Teaching with Technology

With socio-economic and cultural multiplicity in schools today, teaching effectively to accommodate these different levels of ability, background and learning styles is a considerable feat for any teacher. Effective teachers draw on a range of resources to support the development of mathematics concepts within the classroom (Anthony & Walshaw 2009:156). Instant precise computations, construction of graphs and symbolic processing using technology has shown to be beneficial in the teaching and learning of mathematics topics and concepts (Forster 2006:148). Generally, teachers recognise technology in their teaching as an important tool for effective mathematics instruction (Franz & Hopper 2007:1; Mistretta 2005:23). In mathematics classrooms, technology influences the mathematics being taught and supports the mathematics learning of learners when integrated appropriately within the classroom (Centre for Technology in Learning 2007:1-2; Li & Edmonds 2005:143; Lin 2008:140-141).

Furthermore, the use of technology has had a far-reaching effect in areas of school mathematics (Anthony & Walshaw 2009:157). For example, by using technology to monitor learners' strengths and weaknesses while solving different types of problems, teachers may encourage success in the classroom. The use of technology in teaching creates new ways of teaching and understanding abstract concepts in addition to addressing multiple learning needs (White Paper 2011b:6). Technology in mathematics teaching creates a stimulating and collaborative learning process which engages learners in the material being taught (Anthony & Walshaw 2009:157; Loch & Donovan 2006:1). Through the use of calculators, computers and dynamic software, learners can study complex abstract mathematics concepts (Franz & Hopper 2007:1). Additionally, the use of technology within mathematics classrooms, when integrated suitably with teaching methods, policy documents and assessments, has proved to support learning and has demonstrated an improvement in learners' mathematics achievement (Centre for Technology in Learning 2007:1-2; Lin 2008:135).

Methodology

The Participants

This qualitative study was located within an interpretive paradigm to explore postgraduate students' insights into the use of technology in the teaching of mathematics. The population for the study were master's and doctoral mathematics education students registered in the 2012 and 2013 academic years. Student participation was invited from master's and doctoral mathematics education students based at two different campuses within one university. All participants were in-service teachers at primary or secondary school level. Both groups of students were provided with an informed consent form that gave a detailed description of what would be expected of the participants during the data collection phase.

A total of 30 postgraduate students were invited to participate in the study. Of the 30 postgraduate students who were invited to participate, 22 responded positively. A random sample of five postgraduate students was selected for a pilot study. Data were collected through the use of interactive workshops, a discussion session, a questionnaire and semi-structured interview schedules. After minor adjustments were made to the questionnaire, each of the 17 participants in the main study was asked to complete the questionnaire.

The Research Process and Tools

Workshops

Three workshops were held in 2012 with 22 postgraduate students registered for a master's or doctoral degree in mathematics education. These workshops were held on three Saturdays during semester 1 and semester 2 of the 2012 academic year. The workshops were titled as follows:

1. Trends in the teaching of mathematics at institutes of higher education
2. Improving practice: exploring innovative teaching approaches
3. Teaching tools and resources: using technology effectively in mathematics teaching

Each workshop lasted three hours. The workshops were facilitated by three master teachers. The master teachers in this study were expert teachers as identified by the KwaZulu-Natal department of basic education. Master teachers are experienced teachers with the potential to mentor new teachers. At the workshops, postgraduate students were provided with teaching notes, sample lesson plans, sample assessments and demonstrations of how innovative teaching approaches, teaching tools and resources could be used effectively in mathematics teaching.

The third workshop was followed by a discussion session involving the three master teachers and the 22 participating postgraduate students. During this discussion session participants voiced their views of the three workshops and how learnings from these workshops could be translated into improving their own practice as mathematics teachers. At the end of the discussion session the participants were made aware that they would be invited to complete a questionnaire in the second semester of 2013. This meant that they would each have the opportunity of reflecting on what they had learned from the three workshops with a view of improving their own practice at their schools during the first two teaching terms in 2013. The questionnaire was designed to gauge important insights into what was happening in each postgraduate student's classroom after the students were exposed to innovative teaching approaches, teaching tools and resources in mathematics education.

The Questionnaire

The questionnaire was piloted with five randomly selected participants. These five randomly selected postgraduate students had participated in the interactive workshops in the 2012 academic year. After the reliability and validity of the questionnaire was established, the questionnaire was distributed to the remaining 17 participants for the main study. The distribution of the questionnaires took place during the second semester of the 2013 academic year. The questionnaire consisted of three sections. The first two sections focused on the profile and the infrastructure of the schools at which each postgraduate student taught. This approach was considered important so as to identify common attributes between the schools and to make it possible to analyse the context and social background of each school.

The third section of the questionnaire focussed on the postgraduate student's profile. Here it was important to analyse the experience and exposure each postgraduate student had with using technology to teach in the classroom. The data collected revealed that the participants used different types of technologic resources in the mathematics classrooms at various levels of instruction. This section also provided important data regarding each postgraduate student's training and qualifications with respect to using technology in the classroom. In this section the professional development each of the participants had undergone and the professional bodies of which they were members were also examined. This could provide valuable information for re-envisioning the curriculum for teacher development and preparation at higher education institutions.

The Semi-structured Interview

Each participant was interviewed after individual questionnaires were analysed. The interviews were audiotaped (with each participant's permission) and then transcribed. The purpose of the interview was to probe responses to items on the questionnaire and to gain more clarity on each postgraduate student's insight on the use of technology in the teaching of mathematics. Each interview lasted between 30 and 45 minutes. The interviews were conducted at a venue and time that was suitable to each participant. All interviews took place after teaching hours or on weekends. Each interview began with a few general questions so as to place the participant at ease, and then progressed to specific questions based on individual responses on the questionnaire.

Ethical issues

Gatekeeper access was obtained from the university research office and the

Dean of the School of Education. Each postgraduate student that registered for a master's or doctoral degree in mathematics education in 2012 was provided with an information sheet detailing the purpose and process of the study. The participants were informed that each interview would be audio–recorded and they subsequently gave permission for the interviews to be audio–recorded. Each participant was informed in writing of their right to withdraw from the study. They were also informed that they would be invited to a discussion session on the dissemination of results at the end of the study.

Theoretical Framing

Pedagogic content knowledge in mathematics requires the merging of mathematics content and pedagogy. Within the ambits of mathematics pedagogic content knowledge, this study examined postgraduate students' insights into the use of technology in mathematics teaching. Shulman (1987:8-9) used seven categories to categorise the different kinds of professional knowledge that an effective teacher ought to possess (Van der Sandt & Nieuwoudt 2003:199). Aspects of these categories (Shulman 1987:8-9) were used to frame this article. The categories are the following (adapted from Ball, Thames & Phelps 2008:391):

- General pedagogical knowledge
- Knowledge of learners and their characteristics
- Knowledge of educational and social contexts
- Knowledge of educational purposes and their philosophical and historical grounds
- Content knowledge
- Curriculum knowledge
- Pedagogical content knowledge, the combination of content and pedagogy that is unique to teachers

.

The postgraduate students in the study knew their learners and used this knowledge to reflect on and adapt their lessons to ensure maximum benefit of the learning process for their learners. In order for the postgraduate students to succeed at this undertaking, they needed to have a good knowledge of the content being taught and they needed to know how to teach this content (pedagogic content knowledge) in order for the effective teaching and learning of mathematics to ensue.

It was evident from the interviews and discussion session that the postgraduate students in this study possessed mathematical pedagogical content knowledge which enabled them to convert their own mathematics content knowledge into a form that was comprehensible to their learners; in addition, they were skilled at effectively using resources available to them to support them in explaining mathematical concepts successfully (Bukova-Güzel, Cantürk-Günhan, Kula, Özgür & Nüket Elçí 2013:1; Piccolo 2008:88).

The postgraduate students in the study also demonstrated that they knew what their learners were interested in and how to maintain this interest. Through their knowledge of their learners, the postgraduate students inspired learner collaboration and engagement within the classroom environment. Although many participants (58%) were not formally trained in the integration of technology within the mathematics classroom, the participants in general exhibited sound technological and pedagogical content knowledge.

Coding of the Data

Twenty two postgraduate students attended the three interactive workshops. Five of the 22 participants participated in the pilot study. However, owing to work, study or family commitments only 12 of the 17 participants in the main study completed and handed in the questionnaire. These 12 participants were interviewed using a semi-structured interview schedule. All interviews were audiotaped and transcribed. Three phases of coding were used to analyse the data collected. The first phase involved open coding in order to reveal unanticipated insights from postgraduate students focusing on the use of technology in the mathematics classroom. Next, all data were re-examined using a list of anticipated codes and themes focusing on postgraduate students' insights into the use of technology in the mathematics classroom, and common themes were identified. Finally, the similarities and differences between postgraduate students' responses were compared.

The majority (75%) of the participants used technology for the effective teaching of mathematics in their classrooms. The participants that did not use technology in their teaching (25%) attributed this state of affairs to the lack of facilities and resources at their schools. The participants (PGS 2[1], PGS 8 and PGS 10) indicated that the absence of resources and facilities did not allow them the freedom of choosing to use technology in the classroom.

Findings and Interpretation of Results

An initial interpretation of the data revealed that the majority of participants were using technology in the mathematics classroom. A detailed discussion follows below.

The Workshops

The workshops proved to be both productive and enlightening for the participants. The postgraduate students were inspired and motivated by the workshops and they felt that the workshops were useful in enhancing their pedagogic content knowledge. This feeling was evident from the postgraduate students were asked about their views pertaining to the workshops during the course of the semi-structured interview. The excerpt that follows is a snippet from one postgraduate student's (PGS 1) interview transcripts:

> PGS 1: The workshop has made me re-think … how I teach mathematics in my school … now I am in the process of putting a number of ideas into action ... I have a better understanding of how to integrate technology while teaching algebra ….

[1] Codes were assigned to each participant to ensure anonymity of the participants. Each participant was assigned a number from 1-12 based on the sequence of their interviews. PGS 2: Postgraduate student 2 was the second of the 12 postgraduate students that were interviewed. PGS 8: Postgraduate student 8 was the eighth of the 12 postgraduate students that were interviewed.

The quote provided above demonstrates that on reflecting about what had transpired during the workshop, the postgraduate student was inspired to reflect on how he/she was currently teaching mathematical concepts in the classroom. The postgraduate student was introduced to new ways of teaching mathematics concepts; thus, based on the student's response, his/her pedagogic content knowledge was improved due to an enhanced understanding of how technology may be effectively integrated when teaching mathematics. The postgraduate student's improved pedagogic content knowledge was an indication that a transition from the role of the postgraduate student to that of a mathematics teacher (Piccolo 2008:89) had ensued.

Comments by other participants indicated that they found each workshop beneficial in their development as mathematics teachers. This is evident from the comments that follow:

> PGS 6: … for me, the best of the workshops were some of the discussions that took place around some of the topics ... it was helpful to know what others are doing in their mathematics classrooms ....

> PGS 2: … thanks to all in the class for sharing and letting me learn from each one of them ….

The quotes provided above illustrate that the workshops were valuable: the postgraduate students were exposed to new approaches and innovative ideas and strategies, and they were encouraged to discuss openly what they were doing in their own classrooms. They were allowed to share and socially construct ideas and meaning (Naidoo 2006:94-95) during the workshops.

Furthermore, the participants were excited about what they had learnt from the workshops and they were eagerly planning their future lessons with this new-found pedagogic knowledge as is evident from the extracts that follow:

> PGS 7: … I am going to use what I learnt in my classroom ….

> PGS 8: … the best part of the workshops was learning about the resources available … I also valued the input from other teachers in similar schools to mine … I had the opportunity to hear from others about what was happening in different schools ....
> PGS 8: … I want to find out if my pupils[2] are a little more focused than when I use traditional methods to teach. I think it's time for a change …
>
> PGS 12: … I now have access to lots of material … I now have many ideas … for my own teaching ….

It was evident from the excerpts above that the participants valued the knowledge gained from knowing about the different resources that were available to them as mathematics teachers. It would seem that they appreciated having discussions around what was happening at other schools so that they did not feel isolated (Gaikwad & Brantley 1992:14-15). There was a thirst for knowledge about what was happening in other schools and other teaching contexts. The workshops assisted the participants in gaining additional insights into how to improve their own teaching (Palmer 1993:6).

The Questionnaire

Important information was collected using the questionnaire. From the analysis of the questionnaire it was established that each of the participants taught at schools with the average teacher learner ratio of 1:35. All participants had been teaching between 5 and 30 years. The participants were between 25 and 55 years of age. The data collected demonstrated that all the participants belonged to a professional development body and that all of them had access to computers at their school. A minority of the participants (42%) participated in previous workshops focussing on the use of technology in the mathematics classroom. These workshops were part of their professional development training provided by each of the professional bodies of which they were members. A small percentage of the participants (25%) indicated that their school did not have access to technology to support the teaching and learning of mathematics. Some participants (25%) indicated that they

[2] Another term used for learners in a classroom.

were informally trained by colleagues in the use of technology-based tools for the mathematics classroom.

The Semi-structured Interview Schedule

This research instrument was used to probe responses obtained on the questionnaire. The workshops were also discussed during the interview. The responses to the interview assisted in answering the research question: What are mathematics postgraduate students' insights into the use of technology in mathematics teaching? The insights gleaned from the postgraduate students were organised into four themes as follows.

Technology is Being Used because it is Available and Easy to Use

Technology ought to enhance the learning of mathematics. There is no value in having access to technology and using technology at an elementary level in the classroom; it is important to use technology to ensure that it adds understanding and value to the learning process. Some of the postgraduate students indicated that they used technology in the classroom. However, on probing their use of technology it became evident that a small percentage (25%) of the participants sometimes used technology 'marginally'.

Technology in these instances was used at a very fundamental level and did not add real value to the lesson. In these cases, the use of technology in the classroom had no real impact on the learning process. It would appear that in these cases technology was used because it was easier than using the chalkboard. These comments are substantiated by the following excerpts from the interviews:

> PGS 1: … I use the OHP because it's in my class ….
>
> PGS 4: … yes, I use the data projector to teach my lessons … I don't have to write on the board ….
>
> PGS 7: … I show learners geometry examples on the computer … it's easier than drawing over and over on the board ….

As can be seen, a minority of the postgraduate students (25%) used technology at a marginal level because technology-based tools were available to them. It would appear that in these instances no real thought was given to the value that would be imparted to the learners through the use of the technology-based tool. It was evident from these examples that the postgraduate students used the technology without having a real purpose to ensure the effective teaching and learning of mathematics concepts.

While technology-based tools were used in the mathematics lessons, one must concede that the purpose of using technology in the classroom is to enhance communication, provide access to resources, and guide learners to analyse, visualise or express ideas. Yet, in these instances this was not the case. Rather, the technology-based tools were used as an 'add-on' or at a very rudimentary level, thus it would seem that no real educational goals or milestones were achieved through the use of the technology-based tools in these instances.

Allows the Teacher to Teach the Same Content in New Ways

A significant percentage (58%) of the participants valued the use of technology in the classroom because the use of technology-based tools allowed them to teach the same content in new and interesting ways. The majority of these participants used technology-based tools to teach graphs and proofs in mathematics. The participants commonly believed that technology adds more value to the lesson because the learners, through the use of computer software, were now seeing the evidence of the shifts in graphs and proofs. These comments are substantiated by the excerpts that follow.

> PGS 3: … demonstrates proofs/theorems through dynamic software … instead of just talking about it … we can see the proof ….
>
> PGS 5: … when displaying graphs especially in shift … to show intersection etc. ….
>
> PGS 7: … activity based on dynamic representation because it requires hands-on work from learner ….

> PGS 9: … I use sketchpad … … The workshops provided me with ways to use the data projector in my teaching … as well as how to use it for assessment and what to look for ….

> PGS 12: … I have no formal training in technology; I learnt to use the smart board from a colleague. I use this as another method when teaching shifts in trig graphs ....

In addition to teaching shifts in graphs and proofs in mathematics, the participants also used technology to demonstrate concepts that learners had not seen or been exposed to previously, as is evident in the comments that follow.

> PGS 4: … I use games and video clips to teach maths …,

> PGS 6: … some learners did not know what a prism was … I showed this in 3D on the smart board ….

It was evident from the comments above that the postgraduate students were indeed agents of change (Ertmer & Ottenbreit-Leftwich 2010:267) since they were changing how their learners viewed and learned mathematics. These postgraduate students were exposing their learners to new ideas and innovative strategies to help make mathematics more interesting and fun. It addition, the learners could now see mathematics concepts that were once considered foreign and abstract. Being able to visualise and manipulate 3D objects is seen as an advantage for effective learning (Shallcross & Harrison 2007:76). Thus such activities do not only deepen learners' understanding of mathematics and its applications but also help make mathematical ideas and concepts more meaningful (Huang & Li 2009:171).

Allows for the Creation of New and Interesting Learning Experiences

Most of the postgraduate students (75%) valued the use of technology and were willing to use it in the classroom if it added value to their lessons. This claim is evident from the interview excerpts that follow.

> PGS 3: … lessons must capture the child's interest … I use transparencies to do this ….
> PGS 9: … use the internet for interesting approaches to the topics ….
> PGS 11: … lessons must be made interesting … the use of technology promotes this ….
>
> PGS 5: … my students will accept new technology as long as they value it … it must make a difference to their learning something ….

The comments above exemplify the belief that the use of technology in the classroom assists teachers in teaching mathematics effectively. Technology provides learners with interesting learning experiences (Klopfer, Osterweil, Groff & Haas 2006:9). These learning experiences must provide value to the learning process; they ought to be interactive and allow learners to explore concepts off-line for revision purposes (Shallcross & Harrison 2007:76).

Moreover, it was evident during the interviews that the workshops had an impact on the postgraduate students' pedagogic knowledge. The postgraduate students were introduced to innovative technology-based strategies that fostered a sense of excitement in them. This is apparent from the following excerpts taken from the interview transcripts.

> PGS 4: … I didn't have a good grasp on how to assess my students' knowledge by using these tools before the workshops ... I now see how I can incorporate technology in a meaningful way ….
>
> PGS 10: … now I am amazed at all that I have learned … and what I still have to learn, and what I need to do to use this new knowledge in my maths class ….
>
> PGS 12: … I am finding that many of the tools I am learning about can be adapted into my classroom in some way … I know it has inspired me to have more technology in my classroom just seeing what was done in the workshop ….

The above excerpts demonstrate that the postgraduate students were introduced to knowledge about technological tools that led to a shift in their pedagogic understanding. This correlates with Shulman's (1987:13) notion of pedagogic content knowledge (PCK), according to which PCK ought to involve a shift in teacher understanding from being able to understand content for themselves to being able to clarify this content in new ways so that it can be grasped by the learner in the classroom (Tsamir & Tirosh 2009:22).

Challenges Affecting the Use of Technology in the Classroom

A major challenge associated with the use of technology in the classroom appeared to be the lack of resources and infrastructure at schools. The study revealed that a minority of the postgraduate students (25%) were based at schools which were poorly resourced. According to comments made by the participants during the interview, these challenges had an impact on their choice of instructional strategies they used in the mathematics classroom, as shown in the excerpts that follow:

> PGS 2: I want to use dynamic geometry software[3] to help my learners understand the movement of graphs, but our school does not have electricity … I am forced to just use the board.
>
> PGS 8: Even though I may like to show learners some aspects on Geogebra[4] or sketchpad I can't because there is no data projector … I know how to use a data projector to make mathematics more interesting and understandable but our school does not have a data projector ….
>
> PGS 12: … However, there are struggles … I am interested in using these tools in my teaching but our school does not have them ….

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[3] Dynamic geometry software is used for teaching geometry in a discovery mode. Learners are encouraged to use computer software (such as Geometer's Sketchpad or Geogebra) to construct figures that can be altered by dragging points around the computer screen while the underlying relationships are unchanged.

[4] A type of dynamic geometry software that may be used for teaching geometry in the classroom.

The above excerpts provide evidence that the students are willing to attempt innovative technology-based strategies in the classroom but teaching in poorly resourced schools do not provide opportunities for this. The teacher is thus forced to use traditional methods such as the 'chalk and talk' method. Research (Shallcross & Harrison 2007:76) suggests that electronic presentations are more suitable for effective learning in that through this approach avoids learning issues associated with poor handwriting and legibility of material that are common in 'chalk and talk' methods. The excerpts also highlight that the postgraduate students want to embrace and integrate technology in the classroom and that they possess the necessary pedagogic content knowledge to do so, but their creativity in introducing technology-based instructional strategies in the classroom is affected by their being based in a poorly resourced school (Klopfer *et al*. 2006:7-9).

On analysing the data collected it was evident that while one postgraduate student (PGS 10) lamented the fact that he did not have access to a computer to support him when teaching mathematics, this challenge could have been overcome. Besides being the mathematics teacher at the school, the student was also the school principal. He had access to a computer (as the principal) but felt he did not have access to this computer as a mathematics teacher. This is evident in the interview excerpt that follows.

> PGS 10: … I would like to use a computer to help me teach in the class, but I don't have access to one … there is one computer in the school in the principal's office.

The excerpt above demonstrates that the postgraduate student referred to above (PGS 10) found it challenging to merge his two roles and identities at the school. The postgraduate student did not see his role as the principal as an intersection of his role as the mathematics teacher; thus, the professional identity of this postgraduate student was being challenged (Lopes & Tormenta 2010:53).

Conclusion

This qualitative, interpretive study sought to answer the following question: What are mathematics postgraduate students' insights into the use of technology in mathematics teaching? It was apparent from the data collected that all participants valued the use of technology in mathematics teaching. The participants agreed that through participating in the interactive workshops that introduced and exposed them to trends in higher education, innovative teaching approaches and responsive teaching tools and resources, they were inspired to use technology meaningfully in their own practice. The participants felt that these interactive workshops ought to become part of the module on teaching in their mathematics method lectures at university level.

The participants were also of the view that dialogue around what was happening in other schools and in other mathematics classrooms ought to be encouraged. There was a positive response to hearing about what was happening in other mathematics classrooms. In discussions – both during and after the interactive workshop sessions – the postgraduate students welcomed the idea of sharing teaching strategies and effective teaching tips. It was evident during the discussions that the postgraduate students valued discussions with other teachers who taught in similar school contexts. The participants indicated that they had gained valuable pedagogic knowledge and new ideas from the interactive workshops and discussion sessions. This correlates strongly with Shallcross and Harrison's (2007:73) view that discussion methods are instrumental in improving intellectual learning.

Another insight acknowledged by the postgraduate students was that using technology in the mathematics classroom is more possible now than when they were learners at school. They felt that they were more comfortable with using these innovative tools after being introduced to them and being exposed to demonstrations on how the tools could be used to teach and assess learners. The postgraduate students indicated that they were looking forward to sharing these strategies with their learners.

An additional insight of the postgraduate students was that it is valuable to use technology-based tools in the mathematics classroom in teaching as well as assessing. During the workshops the master teachers demonstrated various technology-based assessment tools that learners may use in mathematics to assess their own learning at various stages at their own pace. This links well with Kaasila and Pehkonen's (2009:212) view that it is important to assess mathematics learners in various ways and that it is equally important for learners to assess and reflect on their own learning.

The participants also felt that the mathematics professional bodies of which they were members ought to include topics such as using technology in the mathematics classroom as part of the scheduled workshops for teachers. Furthermore, they believed that teacher education conferences ought to foreground studies on using innovative methods in the classroom. Such presentations would provide valuable examples for teachers to learn from and emulate in their own classrooms. The postgraduate students felt that if practising teachers had more exposure to and knowledge of technology-based teaching strategies, the more likely they would be to implement these strategies in their classrooms.

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Jayaluxmi Naidoo
Mathematics Education Discipline
University of KwaZulu-Natal
naidooj2@ukzn.ac.za